

The System of Rectangular Surveys

3-1. The extension of the rectangular system of public land surveys over the public domain in the United States has been in progress since 1785. Although few of the original surveys now being made cover extensive areas, all facets of the rectangular system occasionally come into use. For this reason, and to make clear the procedures which have been followed in surveying public lands, a complete discussion of the system is included in this manual. It will be seen that the underlying principle is to provide a simple and certain form of land identification and legal description of the public lands.

GENERAL SCHEME

3-2. The law provides that (1) the public lands of the United States shall be divided by lines intersecting true north and south lines at right angles so as to form townships six miles square; (2) the townships shall be marked with progressive numbers from the beginning; (3) the townships shall be subdivided into 36 sections, each one mile square and containing 640 acres as nearly as may be; and (4) the sections shall be numbered, respectively, beginning with the number 1 in the northeast section, and proceeding west and east alternately through the township with progressive numbers to and including 36 (R.S. 2395; 43 U.S.C. 751).

3-3. In accordance with the foregoing legal requirements, the public lands are surveyed under the method called the system of rectangular surveys, which embraces the following procedure:

(1) The establishment of independent initial points, each to serve as an origin for surveys to be extended in separated localities.

(2) The survey of principal meridians and base lines, originating at the initial points.

(3) The establishment of guide meridians initiated at base lines, and of standard parallels initiated at principal meridians, at intervals short enough to maintain a workable adherence to the legal definition of the primary unit, the township six miles square.

(4) The survey of township exteriors within the framework so established. Townships are numbered to the north or south commencing with number 1 at the base line, and with range numbers to the east or west beginning with number 1 at the principal meridian.

(5) The subdivision of the townships into 36 sections by running parallel lines through the township from south to north and from east to west at distances of one mile. The sections are numbered commencing with number 1 in the northeast section of the township, proceeding thence west to section 6, thence south to section 7, thence east to section 12, and so on, alternately, to number 36 in the southeast section.

3-4. By law, (1) the corners marked in public land surveys shall be established as the proper corners of sections, or of the subdivisions of the sections, which they were intended to designate, and (2) the boundary lines actually run and marked shall be and remain the proper boundary lines of the sections or subdivisions for which they were intended, and the lengths of these lines as returned shall be held as the true length thereof (R.S. 2396; 43 U.S.C. 752). The original corners must stand as the true corners they were intended to represent, even though not exactly where professional care might have placed them in the first instance. Missing corners must be reestablished in the

identical positions they originally occupied. When the positions cannot be determined by existing monuments or other verifying evidence, resort must be had to the field notes of the original survey. The law provides that the lengths of the lines, as returned in the field notes, shall be held as the true lengths, and the distances between identified corner positions given in the field notes constitute proper data from which to determine the position of a lost corner; hence the rule that lost corners are restored at distances proportionate to the original measurements between identified positions. (chapter V, Restoration of Lost Corners.)

3-5. In the sections that follow, the first explanations are with respect to ideal procedure in the rectangular plan. The plan must be modified in various ways in order to begin new work where the initial and closing lines already established by prior survey do not qualify under the current specifications for rectangularity and

closure but cannot now be changed because of the passing of titles based on them. The purpose is to avoid the incorporation of the discrepancies of the older lines in the running of new original surveys.

INITIAL POINTS

3-6. During the period since the organization of the system of rectangular surveys, numbered and locally named principal meridians and base lines have been established as listed in the accompanying table. These bases and meridians are shown on the large wall map of the United States published by the Bureau of Land Management, on a special map entitled "Principal Meridians and Base Lines Governing the United States Public Land Surveys" published by the Bureau, and on the various State maps and topographic maps published by the United States Geological Survey.

Meridians and Base Lines of the United States Rectangular Surveys

Meridian	Adopted	Governing surveys (wholly or in part) in States of	Initial Points					
			Latitude			Longitude		
			°	'	"	°	'	"
Black Hills	1878	South Dakota	43	59	44	104	03	16
Boise	1867	Idaho	43	22	21	116	23	35
Chickasaw	1833	Mississippi	35	01	58	89	14	47
Choctaw	1821	do	31	52	32	90	14	41
Cimarron	1881	Oklahoma	36	30	05	103	00	07
Copper River	1905	Alaska	61	49	04	145	18	37
Fairbanks ¹	1910	do	64	51	50.048	147	38	25.949
Fifth Principal	1815	Arkansas, Iowa, Minnesota, Missouri, North Dakota, and South Dakota	34	38	45	91	03	07
First Principal	1819	Ohio and Indiana	40	59	22	84	48	11
Fourth Principal	1815	Illinois	40	00	50	90	27	11
do	1831	Minnesota and Wisconsin	42	30	27	90	25	37
Gila and Salt River	1865	Arizona	33	22	38	112	18	19
Humboldt	1853	California	40	25	02	124	07	10
Huntsville	1807	Alabama and Mississippi	34	59	27	86	34	16
Indian	1870	Oklahoma	34	29	32	97	14	49
Kateel River ²	1956	Alaska	65	26	16.374	158	45	31.014
Louisiana	1807	Louisiana	31	00	31	92	24	55
Michigan	1815	Michigan and Ohio	42	25	28	84	21	53
Mount Diablo	1851	California and Nevada	37	52	54	121	54	47
Navajo	1869	Arizona	35	44	56	108	31	59
New Mexico Principal	1855	Colorado and New Mexico	34	15	35	106	53	12
Principal	1867	Montana	45	47	13	111	39	33
Salt Lake	1855	Utah	40	46	11	111	53	27
San Bernardino	1852	California	34	07	13	116	55	48
Second Principal	1805	Illinois and Indiana	38	28	14	86	27	21
Seward	1911	Alaska	60	07	37	149	21	26
Sixth Principal	1855	Colorado, Kansas, Nebraska, South Dakota, and Wyoming	40	00	07	97	22	08

Meridians and Base Lines of the United States Rectangular Surveys—Continued

Meridian	Adopted	Governing Surveys (wholly or in part) in States of	Initial Points	
			Latitude	Longitude
St. Helena	1819	Louisiana	30 59 56	91 09 36
St. Stephens	1805	Alabama and Mississippi	30 59 51.463	88 01 21.076
Tallahassee	1824	Florida and Alabama	30 26 03	84 16 38
Third Principal	1805	Illinois	38 28 27	89 08 54
Uintah	1875	Utah	40 25 59	109 56 06
Umiat ³	1956	Alaska	69 23 29.654	152 00 04.551
Ute	1880	Colorado	39 06 23	108 31 59
Washington	1803	Mississippi	30 59 56	91 09 36
Willamette	1851	Oregon and Washington	45 31 11	122 44 34
Wind River	1875	Wyoming	43 00 41	108 48 49

¹ U.S.C. & G.S. station "Initial, 1941" is located S. 66° 44' E., 2.85 feet distant from the initial point of the Fairbanks Meridian. The geodetic station (latitude 64° 51' 50.037" N., longitude 147° 38' 25.883" W.) was inadvertently used as the origin from which to compute positions on the Fairbanks Meridian protraction diagrams.

² The Kateel River initial point is identical with U.S.C. & G.S. station "Jay, 1953";

³ The Umiat initial point is identical with U.S.C. & G.S. station "Umiat, 1953", positions are as published by the United States Coast and Geodetic Survey.

3-7. The rectangular system was initiated in the State of Ohio in 1785 from a point on the west boundary of Pennsylvania, on the north shore of the Ohio River, in longitude 80° 32' 20". The State boundary served as the first reference meridian. A number of other reference meridians and bases were employed in Ohio to govern particular areas for purposes of

disposal. In its early stages the system was somewhat experimental, and Ohio may well be referred to as the proving ground for the present rectangular system of surveys. The rectangular surveys that have no initial point as an origin of township identification are listed in the following table.

Public Land Surveys Having No Initial Point as an Origin for Both Township and Range Numbers

Survey (and year commenced)	Townships numbered	Ranges numbered
Ohio River Survey 1785 (Ohio)	North from Ohio River	West from west boundary of Pennsylvania
U.S. Military Survey 1797 (Ohio)	North from south boundary of military grant.	West from west boundary of the Seven Ranges
West of the Great Miami (Ohio) 1798	North from Great Miami River	East from Ohio-Indiana boundary
Ohio River Base 1799 (Indiana)	North from Ohio River	From Ohio-Indiana boundary and its projection south
Scioto River Base 1799 (Ohio)	North from Scioto River	West from west boundary of Pennsylvania
Muskingum River Survey (Ohio) 1800	1 and 2	10
Between the Miamis, north of Symmes Purchase (Ohio) 1802	East from Great Miami River	North from Ohio River (continuing numbers from Symmes Purchase)
Twelve-Mile-Square Reserve (Ohio) 1805	1, 2, 3, and 4	None

PRINCIPAL MERIDIAN

3-8. A principal meridian is intended to conform to the true meridian, extending north or south, or in both directions, from the initial point as conditions require. Regular quarter-

section and section corners are established alternately at intervals of 40 chains, and regular township corners at intervals of 480 chains. Corners designated as meander corners are established at the intersection of the line with meanderable bodies of water.

3-9. In the survey of the principal meridian and other standard lines (base lines, standard parallels, and guide meridians), two independent sets of measurements are made, but only the mean of the two measurements is shown in the final field notes. Double measurement may be omitted if subdivisional closings are provided in the same assignment with the standard line, in which case the closings furnish a verification of the length.

Should the difference between the two sets of measurements of a standard line exceed 7 links per 80 chains, the line is remeasured to reduce the difference. Should independent tests of the alinement of a standard line indicate that the line has deflected more than 3 minutes from the true cardinal course, the line must be rerun. These are the maximum discrepancies allowable in new surveys.

BASE LINE

3-10. The base line is extended east and west from the initial point on a true parallel of latitude. Standard quarter-section and section corners are established alternately at intervals of 40 chains and standard township corners at intervals of 480 chains. Meander corners are established where the line intersects meanderable bodies of water.

3-11. The manner of making the measurement of the base line and the accuracy of alinement and measurement are the same as required in the survey of the principal meridian. The determination of the alinement of the true latitude curve may be made by the solar method, the tangent method, or the secant method as conditions require. The detailed process is described in the field notes.

STANDARD PARALLELS

3-12. Standard parallels, which are also called correction lines, are extended east and west from the principal meridian, at intervals of 24 miles north and south of the base line, in the manner prescribed for the survey of the base line.

3-13. Where standard parallels previously have been placed at intervals of 30 or 36 miles, and present conditions require additional standard lines, an intermediate correction line is established to which a local name may be given, such as "Fifth Auxiliary Standard Parallel North," or "Cedar Creek Correction Line," run, in all respects, like a regular standard parallel.

GUIDE MERIDIANS

3-14. Guide meridians are extended north from the base line, or standard parallels, at intervals of 24 miles east and west from the principal meridian, in the manner prescribed for running the principal meridian. The guide meridians are terminated at the points of their intersections with the standard parallels. The guide meridian is projected on the true meridian, and the fractional measurement is placed in the last half mile. At the true point of intersection of the guide meridian with the standard parallel a closing township corner is established. The parallel is retraced between the first standard corners east and west of the point for the closing corner, in order to determine the

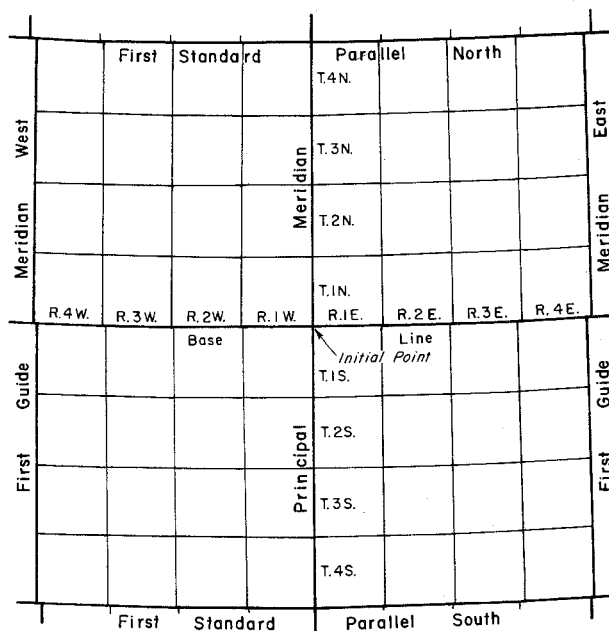


FIGURE 15.—Survey of quadrangles, each embracing 16 townships bounded by standard lines, showing the coordinate system of numbering townships.

exact alinement of the line closed upon. The distance is measured and recorded to the nearest corner on the standard parallel.

3-15. When existing conditions require that guide meridians be run south from the base or correction lines, they are initiated at the theoretical point for the closing corner of the guide meridian, calculated on the basis of the survey of the line from south to north initiated at the proper standard township corner. At the theoretical point of intersection a closing township corner is established.

3-16. Where guide meridians have been placed at intervals exceeding the distance of 24 miles, and new governing lines are required, a new guide meridian is established, and a local name is assigned, such as "Twelfth Auxiliary Guide Meridian West," or "Grass Valley Guide Meridian." Auxiliary guide meridians are surveyed in all respects like regular guide meridians.

TOWNSHIP EXTERIORS

Regular Order

3-17. The south and east boundaries of a township are normally the governing lines of the subdivisional surveys. Defective conditions in previously established exteriors cannot be eliminated where subdivisional lines have been initiated from or closed upon an old boundary, but the errors of former surveys are not incorporated into the new. Where the previously established south and east boundaries cannot on that account be used to govern the subdivision of the adjoining township, other controlling lines known as the sectional correction line and the sectional guide meridian are employed as expedient.

Meridional Boundaries

3-18. Whenever practicable the township exteriors are surveyed successively through a quadrangle in ranges of townships, beginning with the townships on the south. The meridional township boundaries have precedence in the order of survey and are run from south to north on true meridians. Quarter-section and section corners are established alternately at

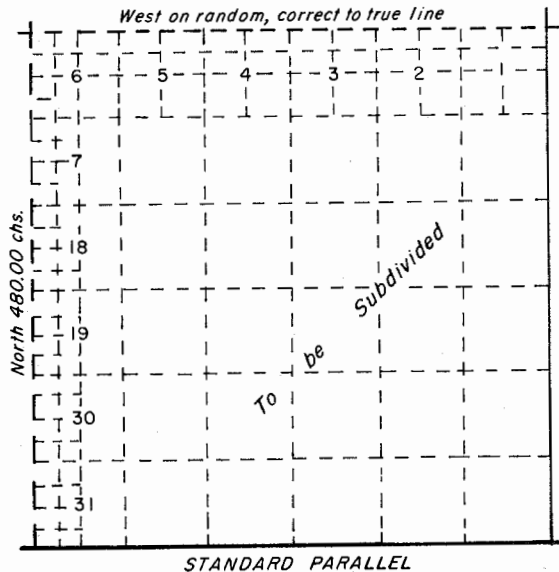


FIGURE 16.—Regular order of completing exteriors where south boundary (standard parallel) and east boundary previously surveyed.

intervals of 40 chains, and meander corners are established at intersections of the line with meanderable bodies of water. A temporary township corner is set at a distance of 480 chains, pending determination of its final position. The temporary point is then replaced by

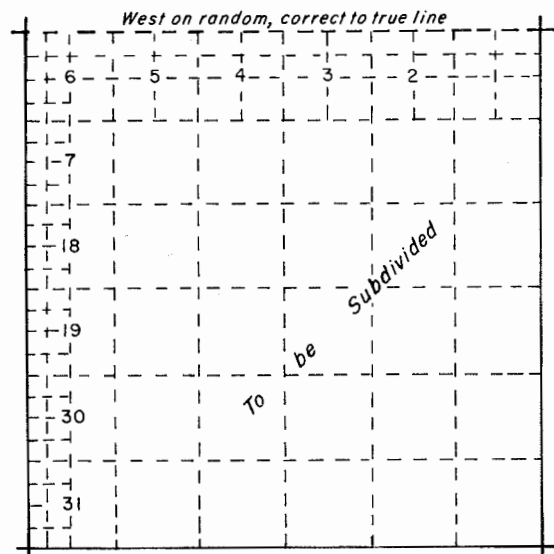


FIGURE 17.—Regular order of completing exteriors where south, east, and west boundaries previously surveyed.

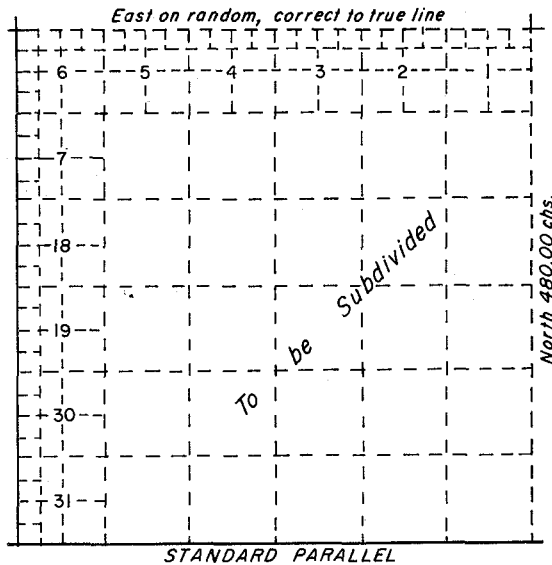


FIGURE 18.—Regular order of completing exteriors where south boundary (standard parallel) and west boundary previously surveyed.

a permanent corner in proper latitudinal position.

3-19. A meridional exterior is terminated at the point of intersection with a standard parallel. The excess or deficiency in measurement is placed in the north half mile. A closing corner is established at the point of intersection. The

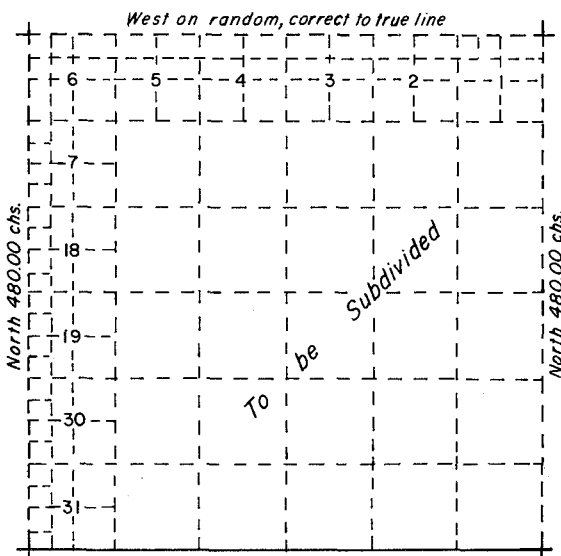


FIGURE 19.—Regular order of completing exteriors where south boundary previously surveyed.

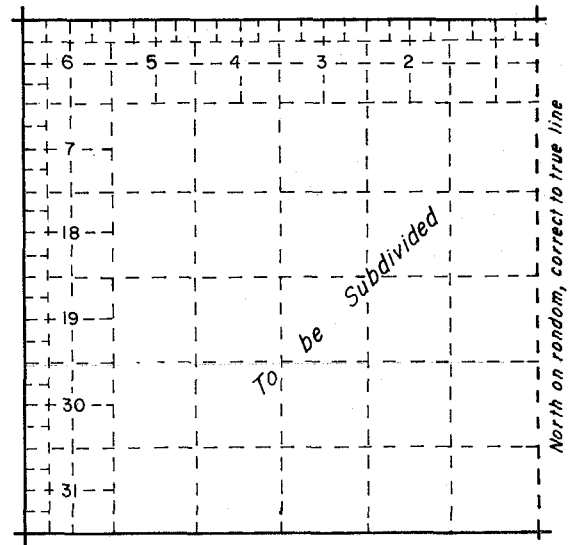


FIGURE 20.—Regular order of completing exteriors where north, south, and west boundaries previously surveyed.

parallel is retraced between the nearest standard corners to east and west to find the exact alinement, and the distance to the nearest corner is measured and recorded.

3-20. In order to complete the exteriors of a township it often remains to establish a meridional boundary between previously established

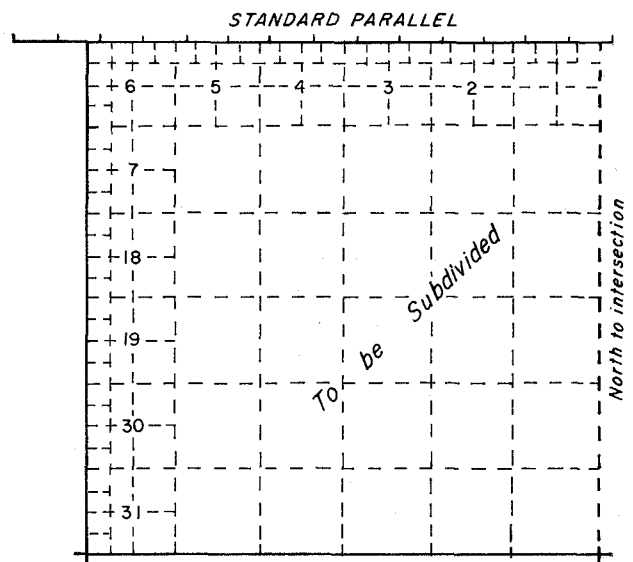


FIGURE 21.—Regular order of completing exteriors where north boundary (standard parallel), south boundary, and west boundary previously surveyed.

township corners. Such boundaries are run from south to north on random lines, with temporary corners set at intervals of 40 chains. If defective conditions are not met with, the random is corrected to a true line. By this procedure, the excess or deficiency of measurement is placed in the north half mile, and double sets of corners are avoided where unnecessary.

Latitudinal Boundaries

3-21. The latitudinal township boundary is run first as a random line, setting temporary corners, on a cardinal course from the old toward the new meridional boundary, and is corrected back on a true line if conditions are ideal. Where both meridional boundaries are new lines or where both have been established previously, the random latitudinal boundary is run from east to west. In either case, if defective conditions are not met with, the random is corrected back on a true line. Regular quarter-section corners and section corners are established at intervals of 40 chains, alternately, counting from the east, and meander corners are set where the true line intersects meanderable bodies of water. The fractional measurement is placed in the last half mile.

3-22. The bearing of the true line is calculated from the falling of the random. The falling is the distance, on the normal, by which a line falls to the right or left of an objective corner. The temporary points on any random line are replaced by permanent corners on the true line. The true line is blazed through timber, and distances to important items of topography are adjusted to correct true line measurement.

Field Notes of Township Exteriors

3-23. The field notes contain a complete record of the manner in which township exteriors have been run and established. The direction of the projection of the random latitudinal curve, the amount of falling, and the calculated return course or true line are recorded in the field tablets but not in the final notes. The final field notes will contain a prefacing statement that random lines are omitted. The details of

offsets, triangulations, and observations may be shown where a special purpose is served.

Irregular Order and Partial Surveys

3-24. It is often necessary to depart from the ideal procedure. The possible combinations are too numerous to state in detail, but where an irregular order appears necessary, the departure from the ideal order is specifically outlined in the special instructions. The departure is always based on the principle of accomplishing the same relation of one township boundary to another as would result from regular establishment under ideal conditions. Some examples are illustrated in figures 22 through 27.

3-25. Where it is impracticable to establish the boundaries in full, it may be necessary to run section lines as offsets to township exteriors. Such lines are run either on cardinal courses or parallel to the governing township boundaries, and even may be established when subdividing, as existing conditions require.

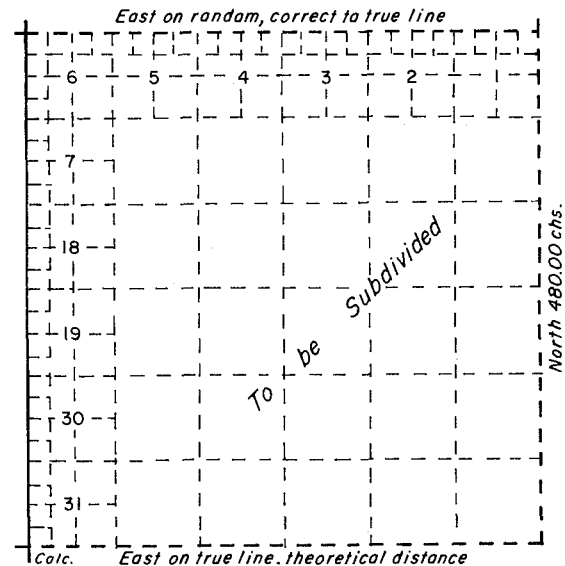


FIGURE 22.—Exception to regular order of completing exteriors; only west boundary previously surveyed.

Allowable Deviation in Bearing

3-26. It is desirable that the alinement of a new latitudinal boundary (which becomes the governing south boundary of the township to the north) shall not depart more than 14' from

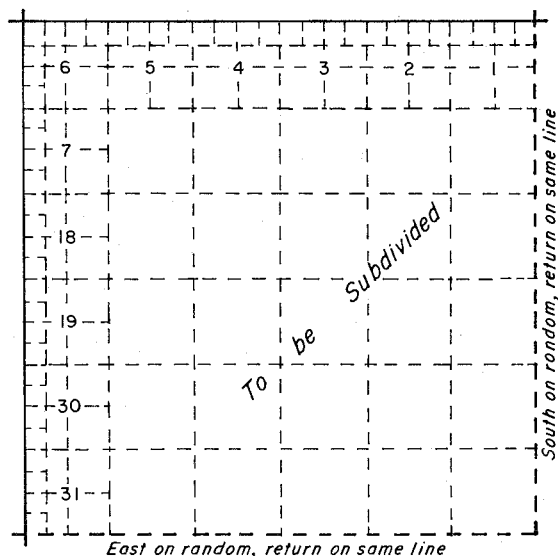


FIGURE 23.—Exception to regular order of completing exteriors; only north and west boundaries previously surveyed.

the true cardinal course. Therefore, the random line, run upon the cardinal course, is made the true line where the falling would otherwise require a correction exceeding 14' of arc. Where the random latitudinal boundary closes on a

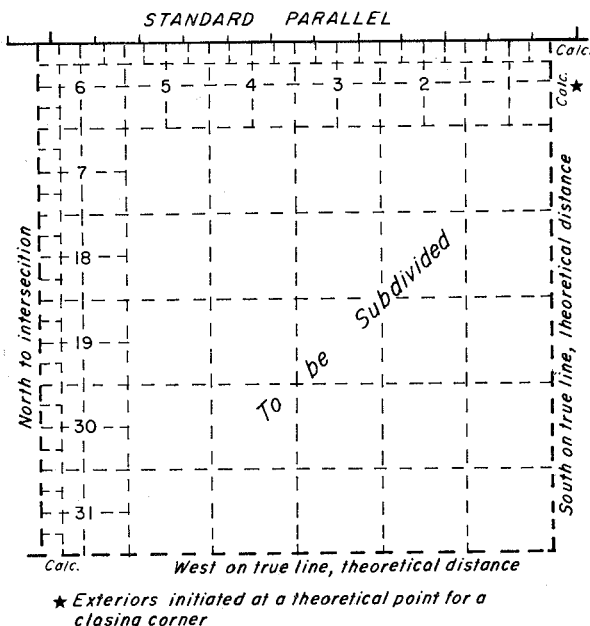


FIGURE 24.—Exception to regular order of completing exteriors; only north boundary (standard parallel) previously surveyed.

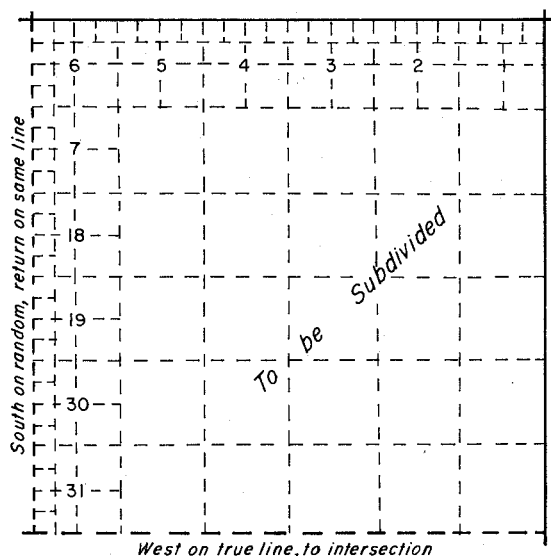


FIGURE 25.—Exception to regular order of completing exteriors; only north and east boundaries previously surveyed.

new meridional exterior, the temporary township corner is adjusted to the latitude of the opposite township corner. But where both meridional boundaries have been previously surveyed, a closing township corner is established

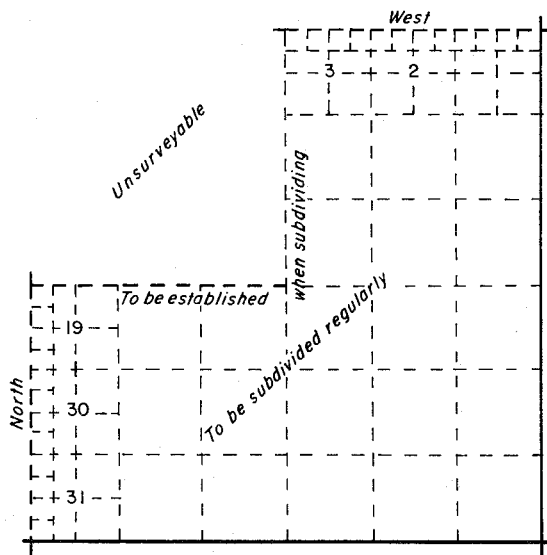


FIGURE 26.—Exception to regular order of completing exteriors; south and east boundaries previously surveyed, but part of township unsurveyable.

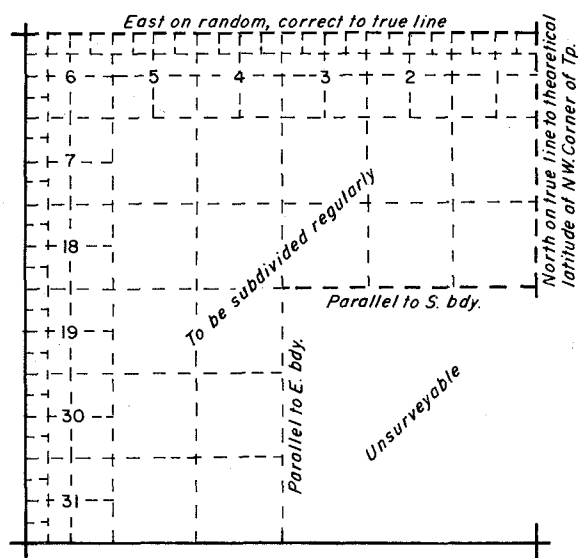


FIGURE 27.—Exception to regular order of completing exteriors; south and west boundaries previously established, but part of township unsurveyable.

at the point of intersection of the random latitudinal line with the meridional boundary, or its projection to the north or south as the case may be.

3-27. A random meridional boundary is made the true line if the falling plus the correction for parallelism of the meridional subdivisional lines would result in calculated bearings (in the northernmost miles of the latter lines) in excess of 14' from cardinal. The bearing of a governing east boundary must therefore fall within certain extremes suited to the latitude of the township.

Applying corrections for convergency within a township, taken from table 2, Standard Field Tables:

Latitude 25° N.

1st Mi. Mer. Subdv.	N. 0°14' E.	5th Mi. Mer. Subdv.	N. 0°14' W.
Corr. for Conv.	+00	Corr. for Conv.	-02
E. bdy. may be	N. <u>0°14'E.</u>	E. bdy. may be	N. <u>0°12' W.</u>

Latitude 70° N.

1st Mi. Mer. Subdv.	N. 0°14' E.	5th Mi. Mer. Subdv.	N. 0°14' W.
Corr. for Conv.	+02	Corr. for Conv.	-10
E. bdy. may be	N. <u>0°16' E.</u>	E. bdy. may be	N. <u>0°04' W.</u>

3-28. The 14' limit for exteriors applies only to the establishment of new boundaries. A previously established boundary, every part of which is within 21' of cardinal, is not considered defective in alinement. Even in the case of new exteriors, where the surveyor who establishes the line also subdivides the township of which it is the governing boundary, the margin of 14' may be exceeded to a limited extent if the existing conditions favor keeping within the 21' limit in the subdivisional survey. The purpose of the 14' limit is merely to facilitate the establishment of all subdivisional lines within the prescribed definite limit of 21' from cardinal.

Completion of Partially Surveyed Exteriors

3-29. Where the end portions of a township exterior have been previously surveyed and fixed in position by use, the fractional unsurveyed middle part is completed by random and true line without offset regardless of the deviation from cardinal direction. The fractional measurements are placed as a general rule in the north or west half miles, as the case may be, thereby permitting the subdivisional lines to be extended as usual from south to north or from east to west.

3-30. Where a fractional part of an exterior remains unsurveyed at either end of the line, a trial random line is projected in a cardinal direction from the previously established terminal corner toward the objective township corner. The random is corrected to a true line where the calculated bearing of any subdivisional line governed by the exterior comes within 14' from cardinal direction. If this condition cannot be met, or if no objective township

6 R.B.T.	5 R.B.T.	4 R.B.T.	3 R.B.T.	2 R.B.T.	1
7					12
18					13
19					24
30 N.0°12'E.					25
31 N.0°12'E.	32 N.0°12'E.	33 N.0°12'E.	34 N.0°13'E.	35 N.0°14'E.	36 N.0°14'E.

Latitude 25°N.

6 R.B.T.	5 R.B.T.	4 R.B.T.	3 R.B.T.	2 R.B.T.	1
7					12
18					13
19					24
30 N.0°14'W.					25
31 N.0°14'W.	32 N.0°14'W.	33 N.0°15'W.	34 N.0°15'W.	35 N.0°12'W.	36 N.0°12'W.

6 R.B.T.	5 R.B.T.	4 R.B.T.	3 R.B.T.	2 R.B.T.	1
7					12
18					13
19					24
30 N.0°06'E.					25
31 N.0°06'E.	32 N.0°08'E.	33 N.0°10'E.	34 N.0°12'E.	35 N.0°14'E.	36 N.0°16'E.

Latitude 70°N.

6 R.B.T.	5 R.B.T.	4 R.B.T.	3 R.B.T.	2 R.B.T.	1
7					12
18					13
19					24
30 N.0°14'W.					25
31 N.0°14'W.	32 N.0°12'W.	33 N.0°10'W.	34 N.0°08'W.	35 N.0°06'W.	36 N.0°04'W.

FIGURE 28.—Illustrating the adjustment in the direction of the meridional lines of a subdivisional survey on account of convergency of meridians, also the 14' limit of the rectangular "safety zone."

corner has been previously established, the partially surveyed exterior is completed on a cardinal course. In either case the fractional measurement is generally placed in the north or west half mile.

Retracements and Resurveys Before Subdividing

3-31. If there is reason to question the accuracy of previously surveyed township exteriors or the condition of the corner monuments,

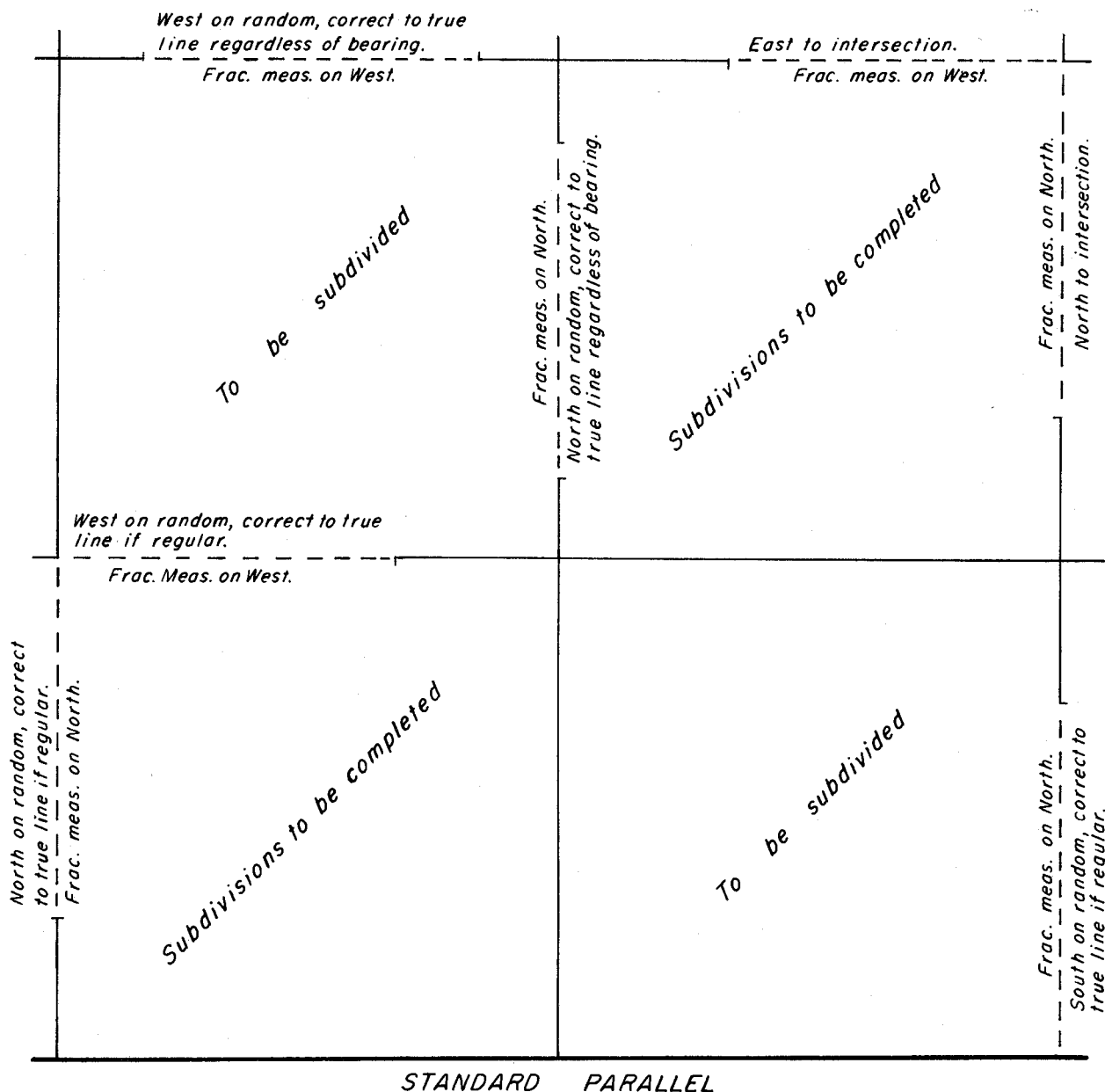


FIGURE 29.—Representative cases of incomplete township exteriors showing methods for completion.

the special instructions should call for the surveyor to reestablish missing corners, remonument dilapidated corner monuments, determine the direction and length of all lines, furnish data needed for the computation of areas of fractional lots, and recommend any improvements indicated for the plan of subdivision.

3-32. All resurvey data are embodied in the

field notes and shown upon the plat of the survey unless the retracement results are in substantial agreement with the record of the original surveys. In the latter case, a statement to the effect is made in the field notes, and the original record governs the data placed on the plat.

Rectangular Limits

3-33. Before discussing the subdivision of townships it is necessary to consider the requirements of law relative to rectangular surveys, wherein the square mile, or section, is the unit of subdivision. The normal township includes 36 sections, only 25 of which are returned as containing 640 acres each. Sections against the north and west boundaries, except section 6, contain regular aliquot parts totaling 480 acres with four additional fractional lots in each section. Section 6 contains regular aliquot parts totaling 360 acres with seven additional fractional lots.

3-34. It has been necessary to establish a definite relationship between rectangularity as contemplated by law and the unit of subdivision resulting from a survey on the earth's surface. The ideal section is allowed to give way to one that is termed "regular." The amounts by which a section, or its aliquot parts, may vary from the ideal section and still be considered regular are referred to as the *rectangular limits*:

(1) For *alinement*, the section's boundaries must not exceed 21' from cardinal in any part, nor may the opposite (regular) boundaries of a section vary more than 21'.

(2) For *measurement*, the distance between regular corners is to be normal according to the plan of survey, with certain allowable adjustments not to exceed 25 links in 40 chains.

Township exteriors, or portions of exteriors, are considered defective when they do not qualify within the above limits. It is also necessary, in order to subdivide a township regularly, to set a third limit, as follows:

(3) For *position*, the corresponding section corners upon the opposite boundaries of the township are to be so located that they may be connected by true lines which will not deviate more than 21' from cardinal.

The rectangular limits should not be confused with the allowable error of closure discussed under sections 3-46 and 3-124.

3-35. A previously established exterior is not defective if the above limits are satisfied. If the rectangular limits have already been exceeded, or the danger point is likely to be reached at an early stage in the subdivisional

survey, the necessary corrective steps are taken before subdividing.

Defective Exteriors

3-36. Township boundaries already established may be defective in alinement, measurement, or position. A defective boundary not previously closed upon and from which subdivisional lines have not been initiated is obliterated after being superseded by survey of a new boundary and connection of the old with the new monuments. If it is known that a mineral survey, homestead entry survey, small holding claim, right of way, reservoir, or other survey has been connected with a corner of an exterior subject to rectification, the fact is stated in the special instruction. In such a case the marks "A M" (signifying "amended monument") are added to the original corner monument, and the old corner is connected by course and distance to the new. A record of the connection is placed in the field notes together with a full description of the monument and its accessories. Where a special purpose is served, the position of the old monument is shown on the plat of the survey.

3-37. If a boundary is defective in measurement or position and is not subject to rectification, the location of the original corners cannot be changed, but the marks on the monuments and the marks upon (or position of) the accessories are appropriately altered to stand only for the sections of the previously established surveys. New corners to control the surveys of the adjoining township are established on the old line at regular distances of 40 and 80 chains. Where new corners are placed on an oblique exterior, whose bearing departs more than 1° from cardinal, they are so located for measurement that the *cardinal* equivalents are 40 and 80 chains.

3-38. Where subdivisional lines have been initiated from or closed upon one side of only a portion of a township boundary, the remaining portion may be superseded if it is found to be defective.

3-39. The position of the new exteriors, or of corners set on defective township boundaries in the new survey, must be established by an actual rerunning of the lines. Data acquired in

surveying subdivisional lines closing upon a defective exterior is not acceptable in lieu of re-tracement or resurvey.

3-40. The south boundary of a township is regularly the governing latitudinal boundary unless defective in alinement. If the boundary is defective in measurement, and not subject to rectification, the original corners are changed to refer only to the sections of the township to the south. New corners of two sections and quarter-section corners of sections of the township to the north are established at regular intervals of 40 chains, counting from the east, and the excess or deficiency in measurement is placed in the west half mile. If the south boundary is defective in alinement, a sectional correction line is required.

3-41. The east boundary of a township is regularly the governing meridional boundary unless defective in alinement. If the boundary is defective in measurement, and not subject to rectification, the original corners are changed to refer only to the sections of the township to the east. New corners of two sections and quarter-section corners of the sections of the township to the west are established at regular intervals of 40 chains, counting from the south. If the east boundary is defective in alinement, a sectional guide meridian is required.

3-42. New east and south boundaries of a township become the closing meridional and latitudinal boundaries of the townships to the east and south respectively. Where doubt exists as to how unsurveyed lines may close, the corners are established only for the sections of the townships of which the new lines are the governing boundaries. The corners of the sections upon the opposite side are established as closing corners at the time of subdivision of the adjoining townships if the original corners are found to be defective in position. If regular connections can be made at that time, the marks on the original monuments are altered to signify corners of maximum control.

3-43. Where the previously established north or west boundaries are defective in measurement or position and subdivisional surveys have been initiated from them, the original corners are changed to refer only to sections to the north or west, respectively. Closing section

corners are established when subdividing. New quarter-section corners are placed on the old line at the mean distances between closing section corners, or at 40 chains from one direction, depending upon the plan of subdivision of the section. Where the previously established north or west boundaries are defective in alinement, but not in measurement or position, no changes are required. The section lines of the township which is being subdivided are connected regularly to the the original corners. Fractional measurements are placed in the north and west half miles.

3-44. Figures 30 through 37 illustrate the guiding principles involved in establishing new governing boundaries where the previously surveyed exteriors are defective. Each diagram illustrates a simple condition affecting one boundary only, and the examples are taken only from the regular order of procedure. Figure 38 shows a series of conditions which might occur in the field. Combinations of defective conditions are best analyzed by breaking them down into the several simple defective conditions. The same holds true in the establishment of township exteriors under an irregular order of procedure. Where extraordinary conditions are encountered which cannot be solved in this manner, the surveyor should report the facts to the proper administrative office, which will issue appropriate instructions.

3-45. The rules for completion and rectification of township exteriors are intended to secure the most direct return to normal procedure. The preliminary retracements and resurveys may show that some modification will obtain better results. Approval of the modified plan should be obtained from the proper administrative office. Each case should be treated on its own merits.

Tables of Latitude and Departure and Closing Errors

3-46. Upon the completion of the survey of one or more township exteriors closing the figure of either a full or fractional township, a table of latitudes and departures will be prepared with allowance for convergency of meridians. The maximum tolerable error of closure is $1/1280$ of the perimeter in either latitude or

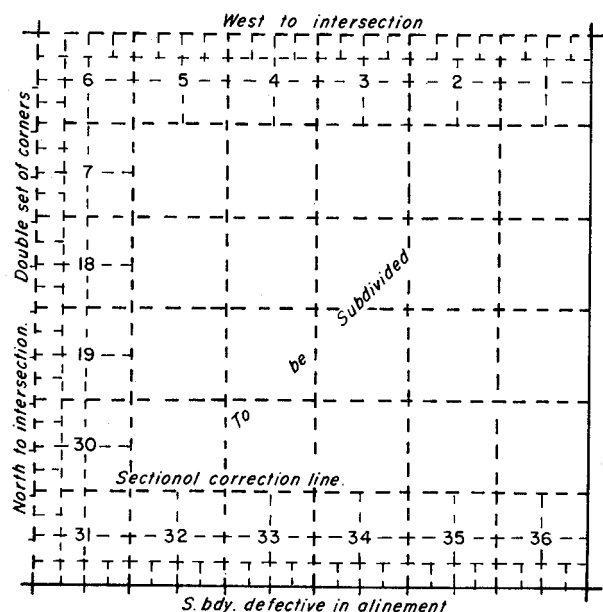


FIGURE 30.—Rectification of fixed south boundary defective in alinement.

departure. If the limit is exceeded, additional retracements or other corrective steps may be necessary to perfect the survey. The table of latitudes and departures and closing errors, including every part of any closed figure embrac-

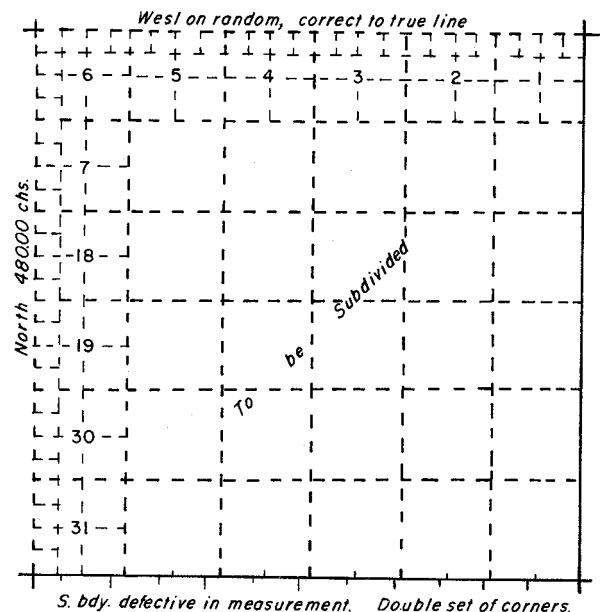


FIGURE 31.—Rectification of fixed south boundary defective in measurement.

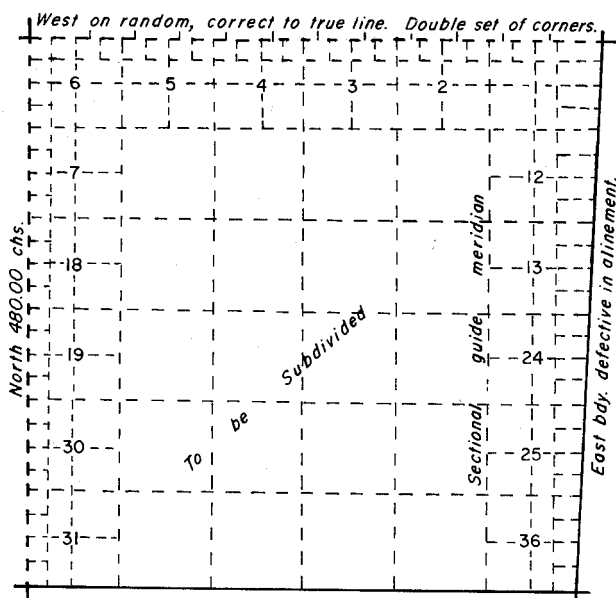


FIGURE 32.—Rectification of fixed east boundary defective in alinement.

ing township exteriors, should be returned with the field tablets and computation sheets.

SUBDIVISION OF TOWNSHIPS

Regular Boundaries

3-47. The boundaries of a township are within satisfactory governing limits for control of the subdivisional survey when the lines may be theoretically projected from the boundaries without closely approaching the rectangular limits. The danger zone has already been placed at theoretical bearings exceeding 14' from cardinal, and the corresponding zone in respect to lengths of lines may be placed at theoretical adjustments exceeding 33 links per mile.

Meridional Section Lines

3-48. These lines have precedence in the order of survey. They are initiated at the section corners on the south boundary of the township and are run north parallel to the governing east boundary. Meridional lines are numbered counting from the east and are surveyed successively in the same order. If the east boundary is within limits, but has been found by

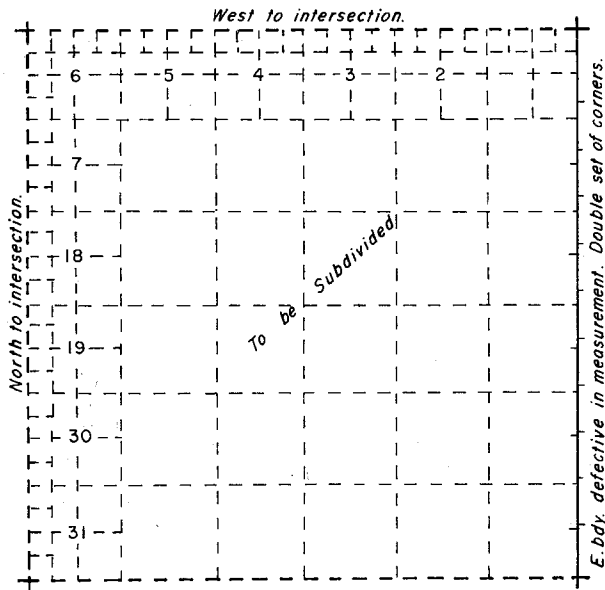


FIGURE 33.—Rectification of fixed east boundary defective in measurement.

retracement to be imperfect in alinement, the meridional section lines are run parallel to the mean course. Regular quarter-section and section corners are established alternately at inter-

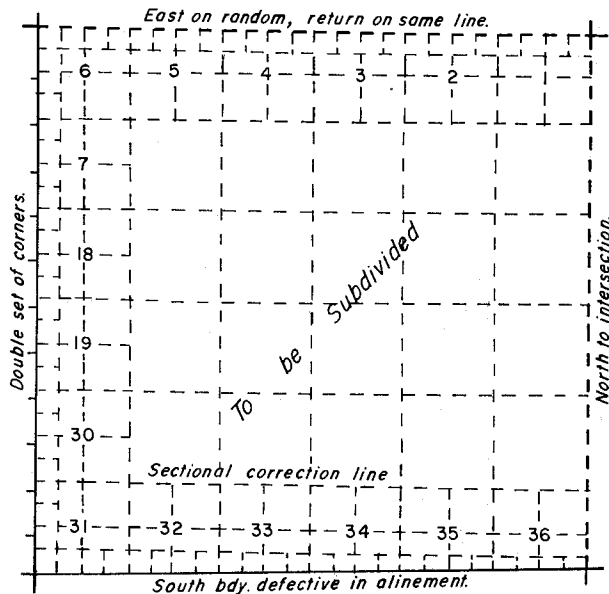


FIGURE 34.—Rectification of south boundary defective in alinement where both south and west boundaries fixed in position.

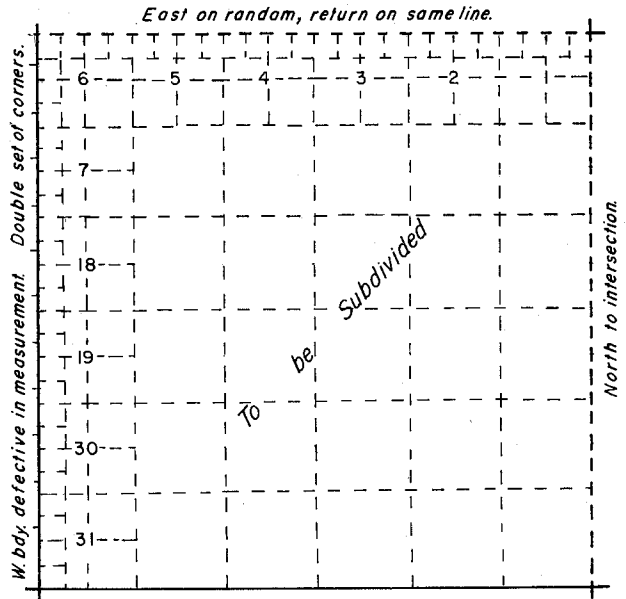


FIGURE 35.—Rectification of west boundary defective in measurement where both south and west boundaries fixed in position.

vals of 40 and 80 chains as far as the northernmost interior section corner.

3-49. A meridional section line is not continued north beyond a section corner until after

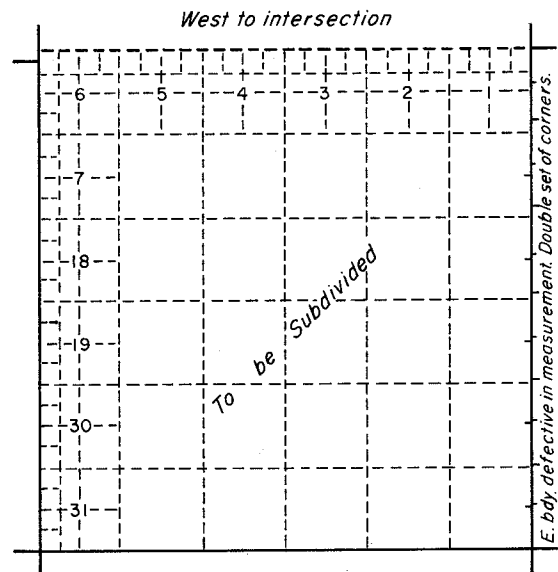


FIGURE 36.—Rectification of east boundary defective in measurement where east and south boundaries fixed in position.

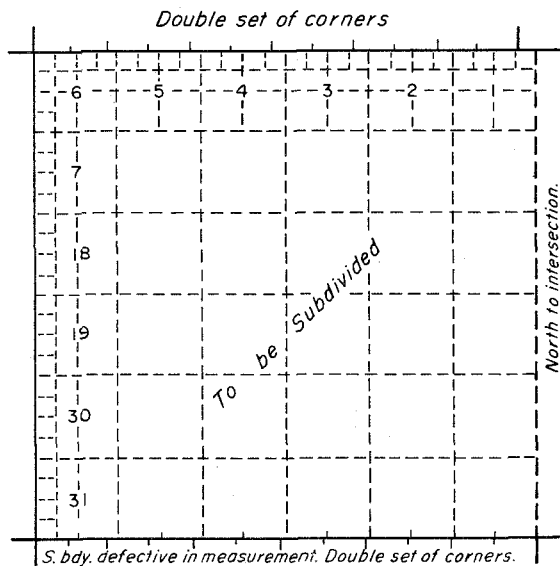


FIGURE 37.—Rectification of south boundary defective in measurement where south, north, and west boundaries fixed in position.

the connecting latitudinal sectional line has been surveyed. In the case of the fifth meridional section line, both latitudinal section lines connecting east and west are surveyed before continuing with the meridional line beyond a section corner. The successive meridional lines are surveyed as convenient, but none should be carried beyond uncompleted sections to the east.

3-50. The last mile of a meridional line is continued as a random line, without blazing through timber, each successive random line being parallel to the true east boundary of the section to which it belongs. A temporary quarter-section corner is set at 40 chains, the distance is measured to the point of intersection of the random line with the north boundary of the township, and the falling of the random line east or west of the objective section corner is noted. The random is then corrected to a true line by blazing through timber and permanently establishing the quarter-section corner on the true line at a distance 40 chains from the south, placing the fractional measurement in the north half mile.

3-51. Where the north boundary of the township is a base line or standard parallel, the last miles of the meridional section lines are

continued as true lines parallel to the east boundary of the township. Permanent quarter-section corners are established at 40 chains from the south, and closing corners are established at the points of intersection with the north boundary. The distance is measured to the nearest standard corner in each case. New quarter-section corners for the sections of the township being subdivided are established at mean distances between closing corners, or at 40 chains from one direction, depending on the plan of the subdivision of the section.

Latitudinal Section Lines

3-52. The latitudinal section lines, except in the west range of sections, are normally run on random lines from west to east, parallel to the south boundaries of the respective sections. Temporary quarter-section corners are set at 40 chains. The distances are measured to the points of intersection of the random lines with the north and south lines passing through the objective section corners; bearings of true lines are calculated on the basis of the fallings. Each random line is corrected to a true line by blazing and marking between the section corners, including the permanent establishment of quarter-section corners at the midpoints on the true lines.

In the west range of sections the random latitudinal section lines are run from east to west, parallel to the south boundaries of the respective sections. On the true lines the permanent quarter-section corners are established at 40 chains from the east, placing the fractional measurements in the west half miles.

Survey Record

3-53. The field notes describing the survey of subdivisional lines are compiled in ranges of sections beginning with the easternmost, and the west two ranges are compiled by alternating with the adjoining east and west sections (figure 39). The field notes contain a complete record of the manner in which the subdivisional lines are run and established. The direction of projection of random lines, the amount of the falling left or right of the objective corner, and the calculated return course or true line are recorded in the field tablets but not in the final

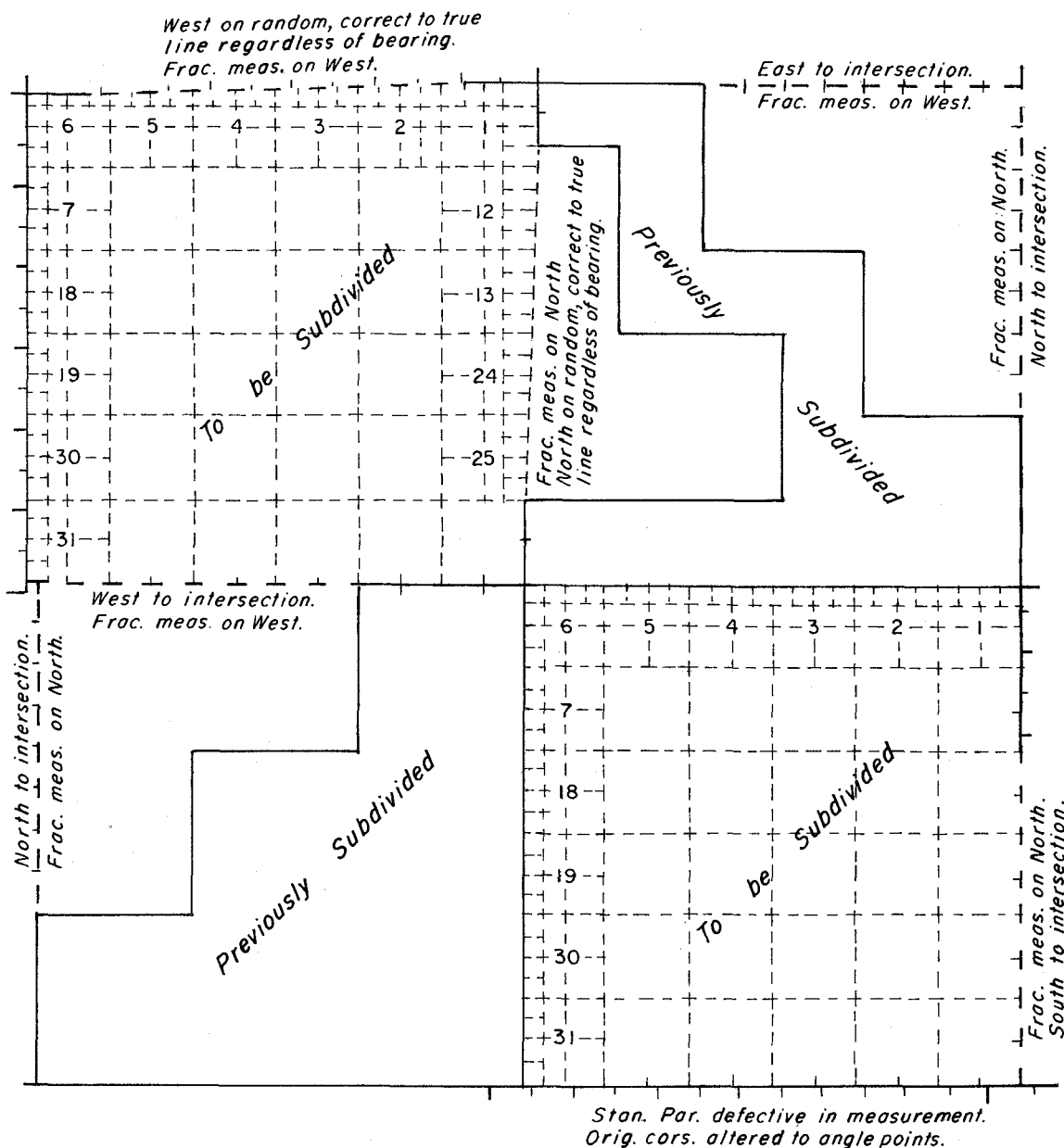


FIGURE 38.—Various defective boundaries, showing methods for completing exteriors.

notes. A prefacing statement in the final field notes will explain that random line field notes are omitted. The details of offsets, triangulations, and observations may be shown where a special purpose is served.

Accumulated Error

3-54. Error in the alinement of the meridional section lines is taken up in part in the

measurement of the latitudinal lines, which must be within 50 links of 80 chains in length, except in the west range of sections where the convergency of the meridional lines is provided for. The accumulated error in alinement for the five miles of true meridional line is taken up in the sixth mile, which is run random and true. Here the true line must be within 21' of cardinal. The slight, ordinary errors in the measure-

6	60	5	44	4	33	3	22	2	11	1
59	58	43	32	21	10					
7	57	8	42	9	31	10	20	11	9	12
56	55	41	30	19	8					
18	54	17	40	16	29	15	18	14	7	13
53	52	39	28	17	6					
19	51	20	38	21	27	22	16	23	5	24
50	49	37	26	15	4					
30	48	29	36	28	25	27	14	26	3	25
47	46	35	24	13	2					
31	45	32	34	33	23	34	12	35	1	36

FIGURE 39.—Sequence of numbers on section lines shows normal order of subdivision.

ment of the meridional lines are taken up by the adjustment of the bearings of the latitudinal section lines, which must be within 21' of cardinal. The accumulated error in measurement in running north is placed in the last fractional half mile. Here the meridional distance is checked by a calculated closing around the last section, and the latitudinal error must not exceed 25 links in order to come within the limits of closure. The limit of rectangularity will be exceeded if the accumulated error is greater than $3\frac{1}{2}'$ in alinement or $8\frac{1}{3}$ links per mile in measurement. Cumulative error must be guarded against and avoided, and the prescribed order of survey furnishes continuous checks upon the accuracy of all lines.

Modifications

3-55. Where the objective section corner is in sight, a random subdivisional line may be run for distance only and the bearing recorded, but the usual rules for running random lines and true lines are observed in every other respect. The random latitudinal section lines, except in the west range of sections, are normally run from west to east, thus always closing upon a previously established section cor-

ner. Under the exigencies of field work, in order to economize the time of his party, the surveyor may project the random from east to west to a temporary section corner set at 80 chains, but the true point for the section corner is determined as usual at the 80-chain point on the meridional section line. The connection of the random latitudinal line and the permanent marking of the true line are completed as regularly provided.

Irregular Boundaries

3-56. Where either of the governing boundaries of a township is disqualified as a controlling line upon which to initiate a subdivisional survey, the necessary retracements and resurveys or alterations are made before subdividing as previously explained under the subject of township exteriors. Every possible provision for a correct subdivisional survey is thereby assured except as either the south or the east boundary is defective in alinement and not subject to rectification.

3-57. The specific plan described below may be modified where conditions justify a change. The basic requirements are (1) adherence to the normal rectangular plan where practicable, (2) a normal location and an area of 640 acres each for granted lands that are identified by the survey (the school sections), (3) the maximum number of regular sections of 640 acres each, or aliquot parts of sections, (4) avoidance of two sets of corners when one set is ample for subdivisional requirements, and (5) simplicity of survey, most readily understood by the public.

Sectional Guide Meridian

3-58. If the east boundary of the township is defective in alinement, and cannot be rectified, the corners on the north boundary will not be properly related to those on the south boundary, even though the measurement of the north boundary is not defective. The north boundary is then said to be defective in position (figure 40). The first meridional line is projected as a sectional guide meridian due north to an intersection with the north boundary, where a closing section corner is established and the

distance measured to the nearest regular corner. The intermediate quarter-section and section corners are established alternately at regular intervals of 40 chains, counting from the south unless the south boundary of the township is itself defective in alinement.

3-59. Where, as shown in figure 41, the north boundary is not defective in position (nor within the danger zone) with reference to the corners on the south boundary (errors in the alinement of the east boundary being compensable), the first meridional section line is projected 5 miles as a true line on a bearing calculated to intersect the objective section corner on the north boundary. The last mile is run as a random line on the same course, and corrected to a true line after the falling has been measured. The remaining meridional section lines are run parallel to the one first established, in the usual manner, to closing section corners on the last mile or random and true as the case may be.

3-60. The fractional measurements of the latitudinal section lines in the first range of sections are placed in the east half mile. Elsewhere, unless the south boundary is defective in alinement, the latitudinal section lines are run in the usual manner.

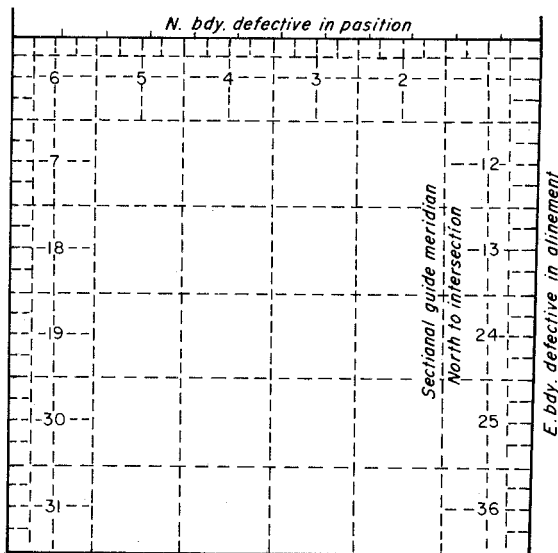


FIGURE 40.—Projection of first meridional section line as guide meridian where defective alinement of east boundary leaves north boundary defective in position.

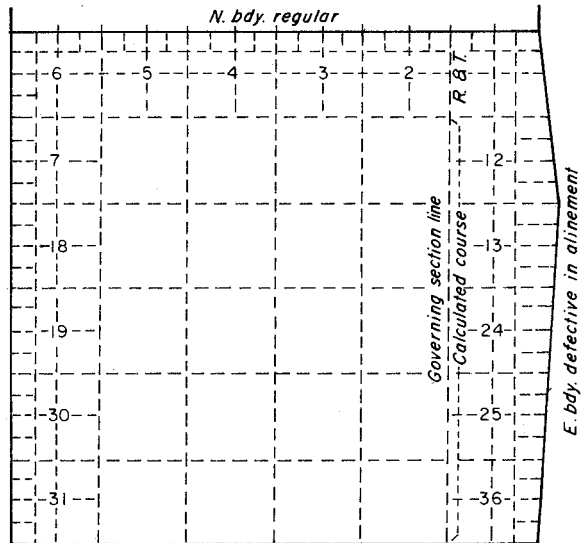


FIGURE 41.—Projection of first meridional section line as governing section line where defective east boundary does not leave north boundary defective in position.

Sectional Correction Line

3-61. If the south boundary of the township is defective in alinement, and cannot be rectified, so that the west boundary is defective in position, a sectional correction line is established (figure 42). This line is surveyed on a true latitudinal curve initiated at the first regular section corner on the east boundary and projected to an intersection with the west boundary of the township, where a closing corner is established and the distance measured to the nearest regular corner. The intermediate quarter-section and section corners are marked as temporary points at regular intervals of 40 chains, alternately, counting from the east.

3-62. Where, as shown in figure 43, the west boundary is not defective in position (nor within the danger zone) with reference to the section corners on the east boundary (errors in alinement of the south boundary being compensable), the first latitudinal section line is projected 5 miles on a bearing calculated to intersect the objective section corner on the west boundary. Temporary quarter-section corners and section corners are marked at regular intervals of 40 chains alternately, counting from the east.

3-63. The section corners on the sectional

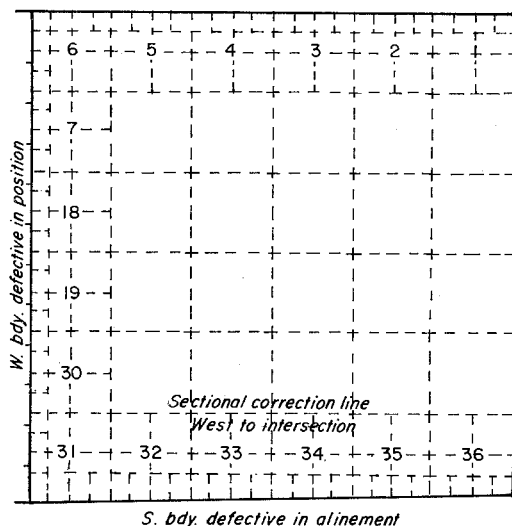


FIGURE 42.—Projection of first latitudinal section line as sectional correction line where defective alignment of south boundary leaves west boundary defective in position.

correction line are established at the points of intersection of the meridional section lines alined in the normal manner. Thereafter, the quarter-section corners on the sectional correction lines are established at the usual midpoints except in the east and west ranges of sections. The quarter-section corner between

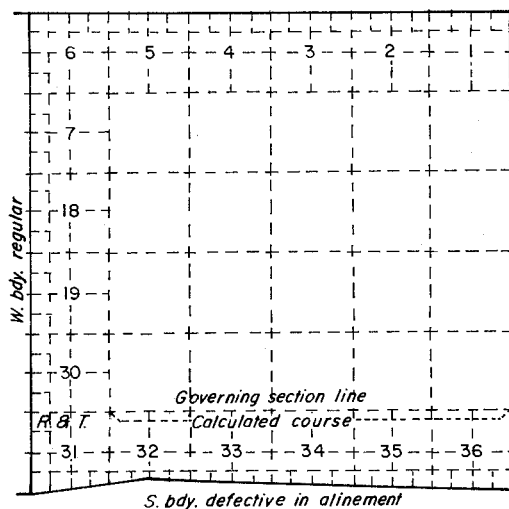


FIGURE 43.—Projection of first latitudinal section line as governing section line where defective south boundary does not leave west boundary defective in position.

sections 25 and 36 is established at 40 chains from the west if the east boundary is defective in alignment. Otherwise it is fixed at the usual midpoint position. The quarter-section corner between sections 30 and 31 is placed at 40 chains from the east. If the sectional correction line has not been terminated at a closing section corner on the west boundary, the line between sections 30 and 31 is run random and true in the normal manner. The quarter-section corners on the meridional section lines in the south tier of sections are established at 40 chains south from the corners on the sectional correction line. The remaining subdivisional lines are continued from the sectional correction line in the usual manner.

Partial Irregularity

3-64. Where the south part of the east boundary, or the east part of the south boundary, is regular, and the balance is defective in alignment and not subject to rectification, the subdivisional survey is made regular as far as possible. The initial point for the sectional guide meridian, or for the sectional correction line, is determined by existing conditions. The first meridional section line is continued as a sectional guide meridian if the north part of the east boundary is defective in alignment and the

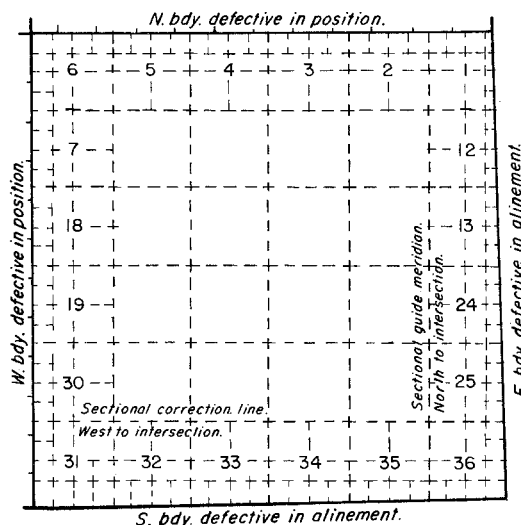


FIGURE 44.—Projection of both sectional guide meridian and sectional correction line where combination of defective conditions exists.

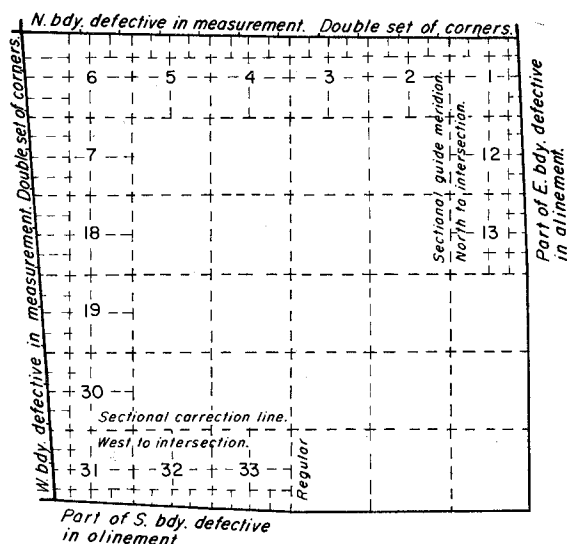


FIGURE 45.—Projection of both sectional guide meridian and sectional correction line in case of partial irregularity.

north boundary is therefore defective in position.

3-65. If the north boundary is not defective in position (nor within the danger zone), the first meridional section line is continued on a course calculated to intersect the objective section corner on the north boundary of the township. The same principle is observed if the west part of the south boundary is defective in alignment, and the west boundary is not defective in position (nor within the danger zone). If the west boundary is defective in position, the sectional correction line is established on the true latitudinal curve.

Summary

3-66. The object of the plan is to secure the maximum number of normal sections. The sections adjoining the east boundary are regular if they conform with the usual rectangular limits. Where that is the case, the quarter-section corners on the latitudinal section lines are placed at the normal midpoint position. The sections adjoining the south boundary of the township are not regular unless the meridional lines are established at 80 chains in length, and the sections are otherwise in conformity with the usual rectangular limits. Exceptions will

be noted under the subject of "fractional subdivision".

Survey Record

3-67. The field notes of subdivisational surveys including a sectional guide meridian, a sectional correction line, or other governing section line, are compiled in the same regular order previously described, but appropriate explanatory remarks are added to show the method and order of procedure.

Closing Section Lines

3-68. Several types of closing lines have been discussed earlier. Guide meridians are closed against standard parallels as a device to avoid the extreme effect of convergency on the breadth of sections (section 3-14). Township and section lines are closed on standard parallels as a part of the same plan (sections 3-19 and 3-51). Both township and section lines may be made closing lines to maintain rectangularity (sections 3-26 and 3-34). A different type of closing line occurs where the lines of the rectangular system of survey cross or close on the boundaries of reservations or grants, State boundaries, or the lines of various kinds of claims.

3-69. Closing corners are normally established at intersections with a surveyed reservation, grant, or State boundary. The bearing and the distance to the nearest corner or angle point of the irregular boundary should always be noted. It is usually necessary to retrace the boundary to the nearest corner in each direction to insure placement of the closing corner at the exact intersection.

3-70. Quarter-section corners are established between closing corners for sections closing on a reservation or grant boundary. Since the Bureau of Land Management has no general authority to survey or resurvey State boundaries, quarter-section corners should not be established between closing corners on State boundaries. Although the closing corners themselves are established, State names should not be marked on the monuments (sections 4-25 and 5-19).

3-71. A closing corner monument is not set at intersection with the line of a surveyed mineral claim, forest homestead claim, small holding claim, or the like, unless required to provide an interval of monumentation of one-half mile or less. In some instances, crossing closing corners may be needed for operational or litigation purposes, in which event they should be provided for in the special instructions.

Where a line of the rectangular survey crosses a surveyed claim, the bearing of the intersected claim line and the distance to the nearest corner are determined and noted. In the case of a claim located entirely within a section, a connection is made from a corner of the claim to a regular corner of the section. If the connection is made by traverse, it is reduced to the equivalent direct course and distance for inclusion in the field notes and plat.

Since the accuracy of lotting in the section depends on a correct location of the claim, it may be desirable to retrace one or all of the claim lines. If a multiplicity of claims exists, their treatment should be covered in the special instructions.

3-72. If a survey is concluded upon an irregular boundary at variance with the lines of legal subdivision, or if the survey is continued on a blank line to acquire a definite location upon the opposite irregular boundary, but without monumenting the rectangular survey between the irregular boundaries, a closing corner is always required at the point of intersection of the regular with the irregular line. On the other hand, if the survey is continued across the reservation or grant for the purpose of establishing a full complement of corners for the control of the subdivision of a section so invaded, a closing corner may not be required.

3-73. Closing corners are intended to be established where a closing line intersects a boundary already fixed in position. While the closing corner thereafter controls the direction of the closing line, a failure to place it at the true point of intersection does not alter the position of the line closed upon but may cause interested parties to rely on the faulty position. The line closed upon should always be

retraced between the first corners to the right and left. Determination of the point of intersection by calculation is not permissible.

SUBDIVISION OF SECTIONS

3-74. Revised Statutes, secs. 2396, 2397 (43 U.S.C. 752 and 753), contain the fundamental provisions for the subdivision of sections into quarter sections and quarter-quarter sections. The sections are not subdivided in the field by Bureau of Land Management cadastral surveyors unless provision is made in the special instructions, but certain subdivision-of-section lines are always protracted upon the official plat.

3-75. Under the rectangular system the unit of survey is the township of 36 sections. The unit of subdivision is the section of 640 acres. Under the general land laws, broadly, the unit of administration is the quarter-quarter section of 40 acres. The function of the cadastral surveyor of the Bureau of Land Management has been fulfilled when he has executed and monumented his survey properly and returned an official record in the form of detailed field notes and a plat. The plats are constructed in harmony with the field notes returned by the surveyor. The lands are identified on the ground by fixed monuments established in the survey. A United States patent conveys the title to an area defined by those fixed monuments and related by description and outline to the official plat.

3-76. The local surveyor is employed as an expert to identify lands which have passed into private ownership. This may be a simple or a most complex problem, depending largely upon the condition of the original monuments as affected principally by the lapse of time since the execution of the original survey. The work usually includes the subdivision of the section into the fractional parts shown upon the approved plat. In this capacity the local surveyor is performing a function contemplated by law. He cannot properly serve his client or the public unless he is familiar with the legal requirements concerning the subdivision of sections. In the event that the original monuments have become lost, the surveyor needs to be familiar with the scheme of the original survey, the

record of the particular survey involved, and the principles upon which the courts have based rulings with regard to corner restorations.

The Bureau of Land Management assumes no control or direction over the acts of local and county surveyors in the matters of subdivision of sections and reestablishment of lost corners of original surveys where the lands have passed into private ownership, nor will it issue instructions in such cases. It follows the general rule that disputes arising from uncertain or erroneous location of corners originally established by the United States are to be settled by the proper local authorities or by amicable adjustment. The Bureau desires that the rules controlling the acts of its own cadastral surveying service be considered by all other surveyors as merely advisory and explanatory of the principles which should prevail in performing such duties.

Subdivision by Protraction

3-77. Upon the plat of all regular sections the boundaries of the quarter sections are shown by broken straight lines connecting the opposite quarter-section corners. The sections bordering the north or west boundary of a normal township, excepting section 6, are further subdivided by protraction into parts containing two regular half-quarter sections and four lots. Section 6 has lots protracted against both the north and west boundaries, and so contains two regular half-quarter sections, one quarter-quarter section, and seven lots. The position of the protracted lines and the regular order of lot numbering are shown in figure 46. The lots are numbered in a regular series progressively from east to west or from north to south in each section. The lots in section 6 are numbered commencing with No. 1 in the northeast, thence progressively to No. 4 in the northwest, and south to No. 7 in the southwest fractional quarter-quarter section.

3-78. The regular quarter-quarter sections are aliquot parts of quarter sections based upon midpoint protraction. These lines are not indicated upon the official plat.

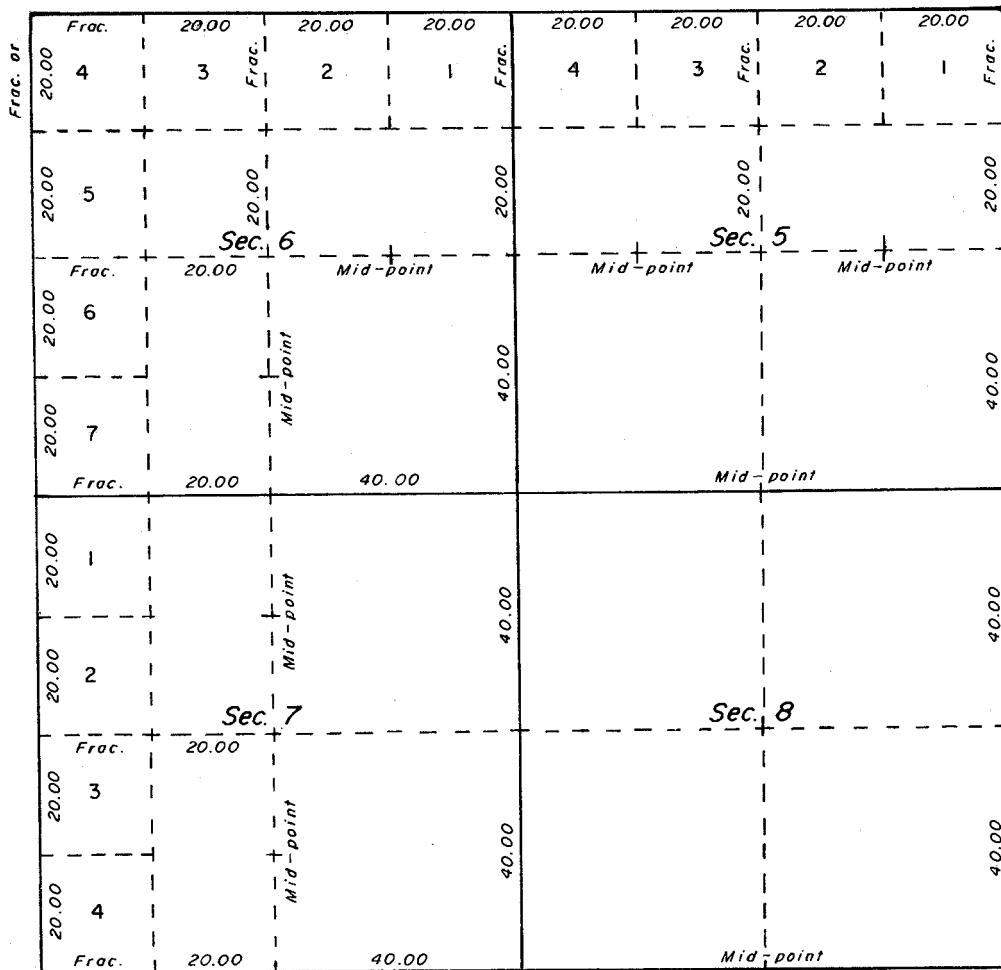
3-79. Sections which are invaded by considerable bodies of water, or by approved claims at variance with the regular legal subdivisions,

are subdivided by protraction into regular and fractional parts as may be necessary to form a suitable basis for the administration of the public lands remaining undisposed of, and to describe the latter separately from the segregated areas.

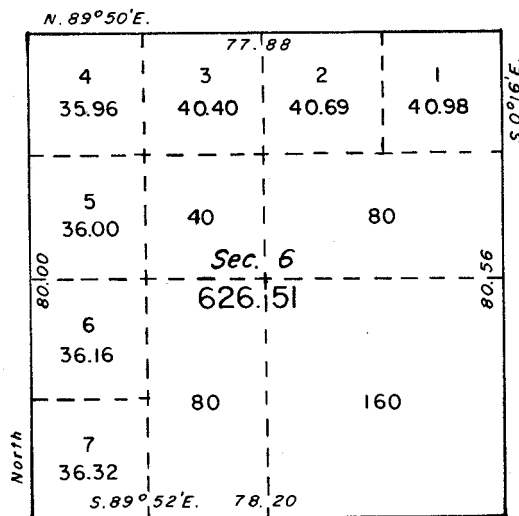
3-80. The meander line of a body of water and the boundary lines of private claims are platted in accordance with the lines run or connections made in the field. The sections invaded are subdivided as nearly as possible in conformity with the uniform plan. The subdivision-of-section lines are terminated at the meander line or claim boundary, but the position of the subdivision-of-section lines is controlled precisely as though the section had been completed regularly. In the case of a section whose boundary lines are in part within the limits of a meanderable body of water, or within the boundaries of a private claim, the fractional section lines are completed in theory, and the protracted position of the subdivision-of-section lines is controlled by the theoretical points so determined.

3-81. Fractional sections are subdivided so as to contain as many aliquot parts as possible, but a departure from this practice is made where it would result in poorly shaped fractional lots. In the case of fractional lots along the north and west boundaries of a township, and in other similar cases where a lot has a full normal width of 20 chains in one direction, it is generally advisable to avoid areas of less than 10 or more than 50 acres. In the instance of fractional lines along a meander line or other irregular broken boundary, where the width of the lot in both directions may be considerably less than 20 chains, resulting in tracts of more compact form, it is generally better to avoid an area of less than five or more than 45 acres. Extreme lengths or narrow widths should be avoided. The longer direction should extend back from a meander line or claim boundary rather than along it. It is inconsistent that a fractional lot lie partly in two sections, and it is generally better, when consistent with other rules, to avoid fractional lots extending from one into another fractional quarter section.

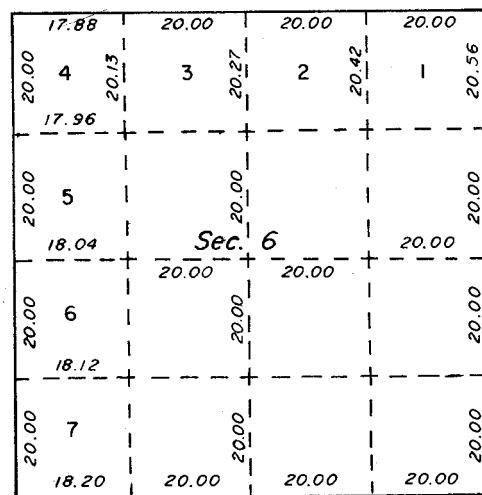
3-82. To visualize a uniform system for numbering lots of fractional sections, imagine



Showing normal subdivision of sections.

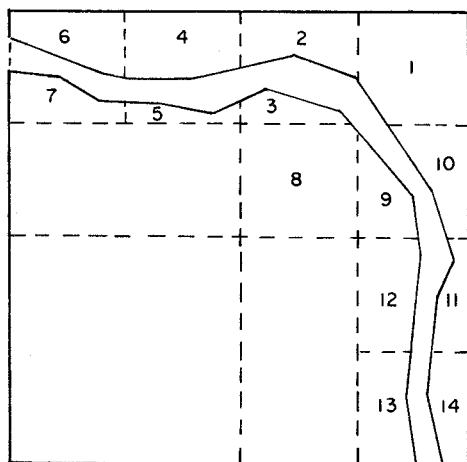


Showing areas.

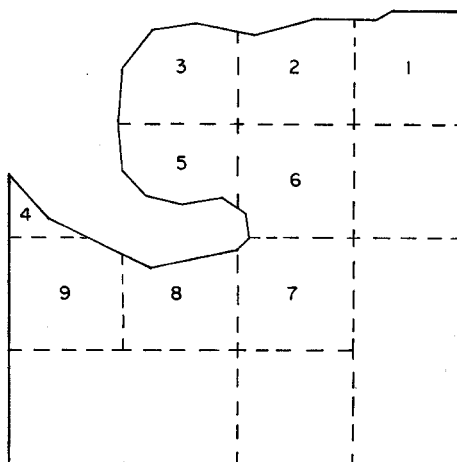


Showing calculated distances.

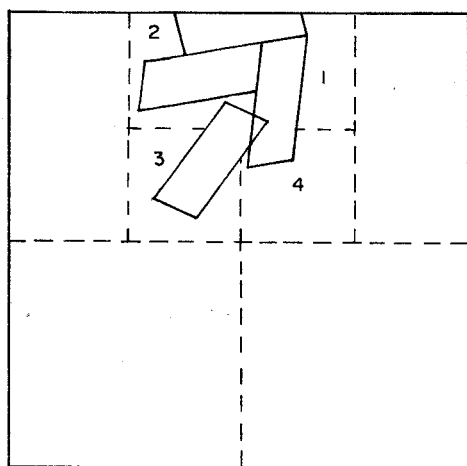
FIGURE 46.—Examples of subdivision by protraction.



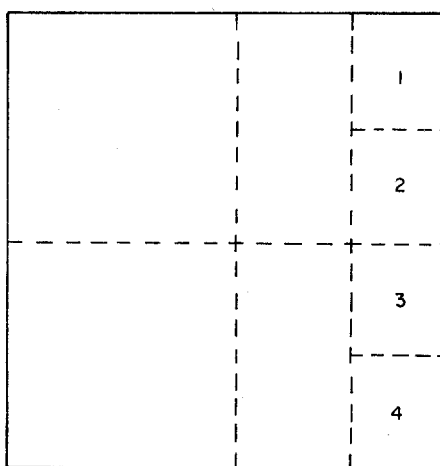
Meanderable River.



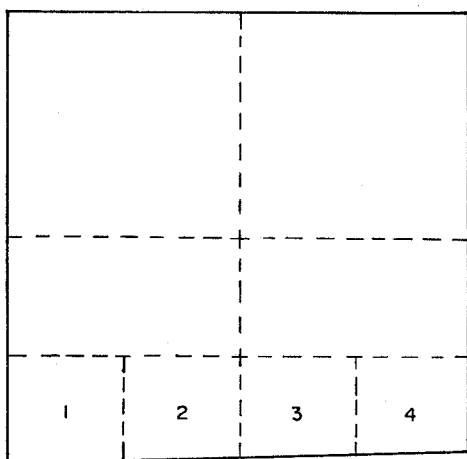
Meanderable Lake.



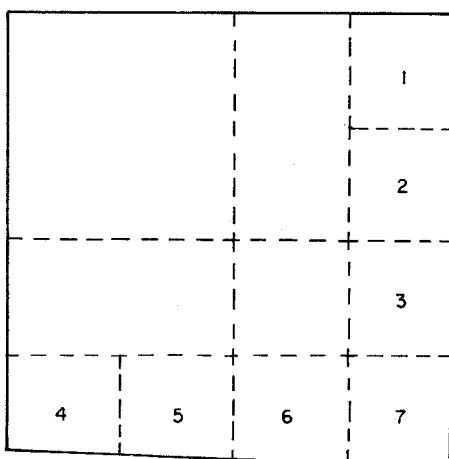
Mineral Claims.



E. bdy. defective in alinement.



S. bdy. defective in alinement.



E. & S. bdrs. defective in alinement.

FIGURE 47.—Examples of subdivision of fractional sections.

the section divided by parallel latitudinal lines into tiers, numbered from north to south. Then, beginning with the eastern lot of the north tier, call it No. 1, and continue the numbering west through the tier, then east in the second, west in the third, east in the fourth tier, until all fractional lots have been numbered. These directions are maintained even though some of the tiers contain no fractional lots. A lot extending north and south through two, or part of two tiers, is numbered in the tier containing its greater area. This method of numbering applies to any part of a section. A section that has been partly surveyed at different times should have no duplication of lot numbers.

8-83. When the length or width of a township exceeds 480 chains to such an extent as to require two or more tiers of lots adjoining the north or west boundary, the usual past practice has been to lot all of the area beyond the regular legal subdivisions as shown in figure 48(a) and 49(a). Henceforth, in order to avoid possible confusion of descriptions, the lotting should be extended throughout the fractional half of the section as shown in figures 48(b) and 49(b). This will also apply to the platting of resurveyed sections insofar as public land is involved. In modern practice, sections in excess of 120 chains are avoided by the creation of half-township or half-range numbers. This cannot be done where the elongated sections are situated in the interior of a township as the result of partially completed but grossly irregular former subdivisions. Lotting will then be extended as necessary.

3-84. If it has been necessary to establish a sectional guide meridian or a sectional correction line, fractional lots may result along the east or south boundary of the township. The sections bordering the defective boundaries are subdivided on the same plan as sections bordering the north and west boundaries of a normal township.

Subdivision by Survey

3-85. The rules for subdivision of sections by survey are based on the laws governing the survey of the public lands. Some cases arise, however, which are not covered by these rules and require the advice of the Bureau of Land

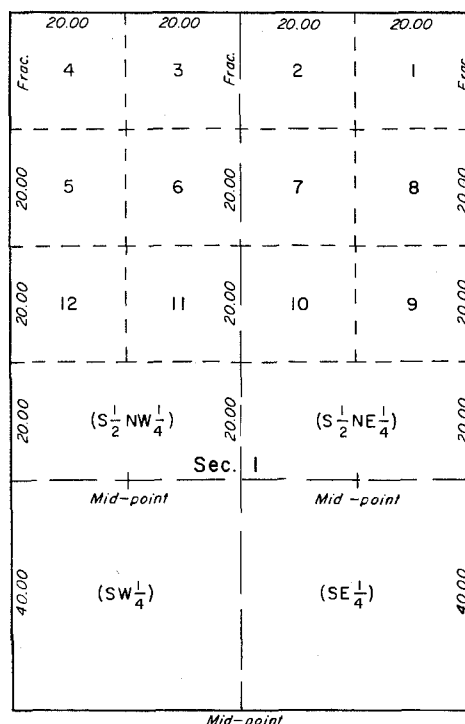


FIGURE 48(a).—Elongated section—subdivision by protraction.

Management. The letter of inquiry should contain a description of the particular tract or corner, with reference to township, range, and section of the public surveys, together with a diagram showing conditions found.

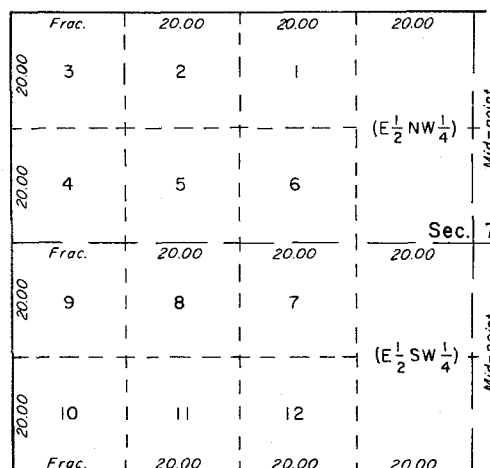


FIGURE 49(a).—Elongated section—subdivision by protraction.

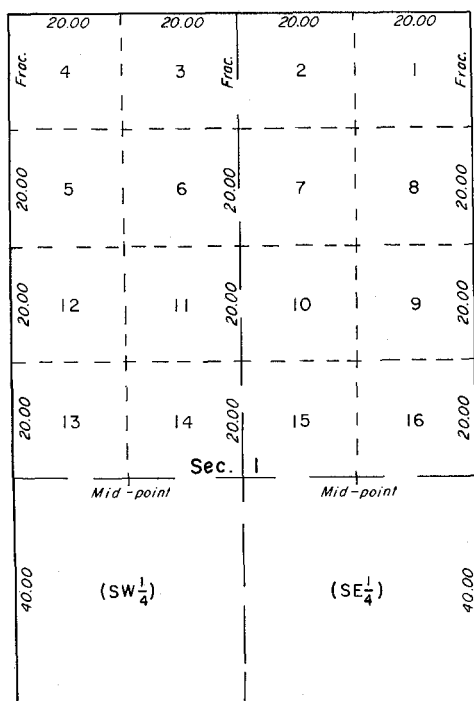


FIGURE 48(b).—Extension of lotting in elongated section.

Order of Procedure in Survey

3-86. Since the corners established in the original survey are controlling, it is essential that these corners be found, or properly restored, before the actual field work involving the subdivision of section is undertaken. The section boundaries should be retraced to develop

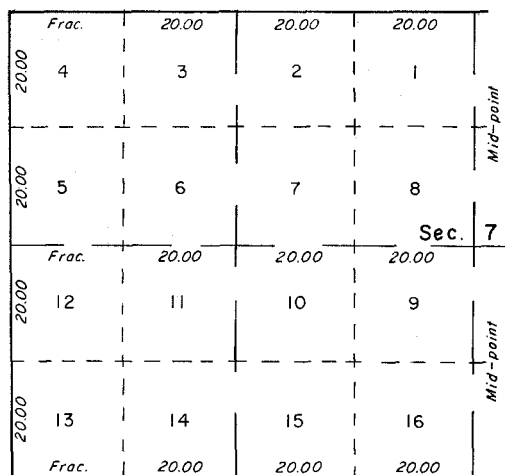


FIGURE 49(b).—Extension of lotting in elongated section.

the actual bearings and lengths of the lines between the corners.

The order of procedure is: First, identify or reestablish the corners on the section boundaries, including determination of the points for the necessary one-sixteenth section corners. Next, fix the boundaries of the quarter sections; and then form the quarter-quarter sections or small tracts by equitable and proportionate division. The following methods should be employed:

Subdivision of Sections Into Quarter Sections

3-87. To subdivide a section into quarter sections, run straight lines from the established quarter-section corners to the opposite quarter-section corners. The point of intersection of the lines thus run will be the corner common to the several quarter sections, or the legal center of the section.

Upon the lines closing on the north and west boundaries of a regular township the quarter-section corners were established originally at 40 chains to the north or west of the last interior section corners. The excess or deficiency in measurement was thrown into the half mile next to township or range line, as the case may be. If such quarter-section corners are lost they should be reestablished by proportionate measurement based upon the original record.

Where there are double sets of section corners on township and range lines, the quarter-section corners for the sections south of the township line and east of the range line usually were not established in the original surveys. In subdividing such sections new quarter-section corners are required, so placed as to suit the calculations of the areas that adjoin the township boundary, as indicated upon the official plat, adopting proportional measurements where the new measurements of the north or west boundaries of the section differ from the record distances.

Subdivisions of Fractional Sections

3-88. The law provides that where opposite corresponding quarter-section corners have not been or cannot be fixed, the subdivision-of-section

tion lines shall be ascertained by running from the established corners north, south, east, or west, as the case may be, to the water course, reservation line, or other boundary of such fractional section, as represented upon the official plat.

In this the law presumes that the section lines are due north and south, or east and west lines, but usually this is not the case. Hence, in order to carry out the spirit of the law, it will be necessary in running the center lines through fractional sections to adopt mean courses where the section lines are not on due cardinal, or to run parallel to the east, south, west, or north boundary of the section, as conditions may require, where there is no opposite section line.

Subdivision of Quarter Sections

3-89. Preliminary to the subdivision of quarter sections, the quarter-quarter- or sixteenth-section corners will be established at points midway between the section and quarter-section corners, and between the quarter-section corners and the center of the section, except on the last half mile of the lines closing on township boundaries, where they should be placed at 20 chains, proportionate measurement, counting from the regular quarter-section corner.

The quarter-quarter- or sixteenth-section corners having been established as directed above, the center lines of the quarter section will be run straight between opposite corresponding quarter-quarter- or sixteenth-section corners on the quarter-section boundaries. The intersection of the lines thus run will determine the legal center of a quarter section.

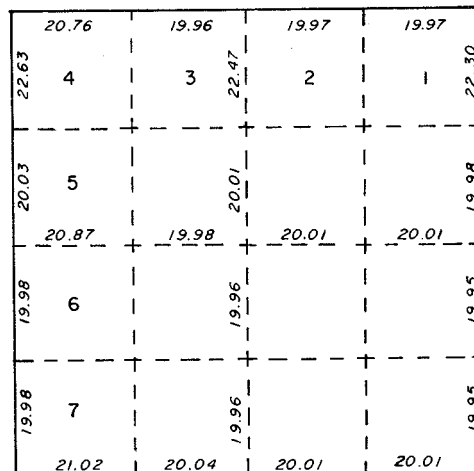
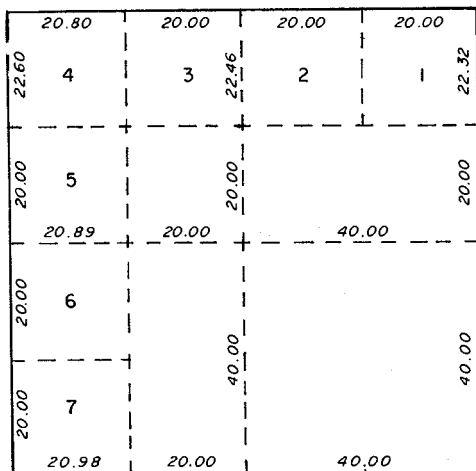
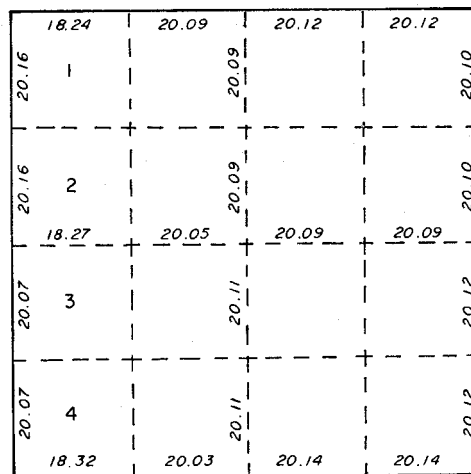
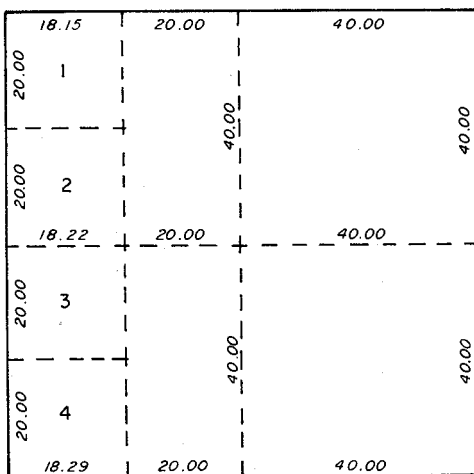
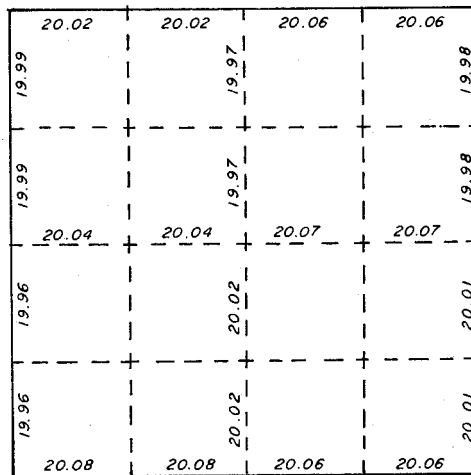
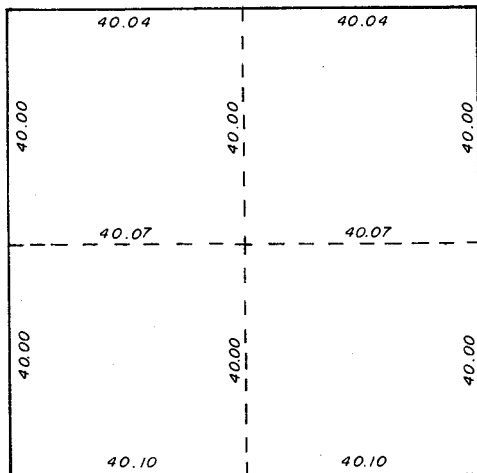
Subdivision of Fractional Quarter Sections

3-90. The subdivisional lines of fractional quarter sections will be run from properly established quarter-quarter- or sixteenth-section corners, with courses governed by the conditions represented upon the official plat, to the lake, water-course, reservation, or other irregular boundary which renders such sections fractional.

3-91. Reasonable discrepancies between former and new measurements may generally be expected when retracing the section boundaries. The shortage or surplus is distributed by proportion in establishing a sixteenth-section corner. For example: The length of the line from the quarter-section corner on the west boundary of section 2 to the north line of the township, by the official survey was reported as 43.40 chains, and by the county surveyor's measurement was found to be 42.90 chains. The distance which the sixteenth-section corner should be located north of the quarter-section corner would be determined by proportion as follows: As 43.40 chains, the official measurement of the whole distance, is to 42.90 chains, the county surveyor's measurement of the same distance, so is 20 chains, original measurement, to 19.77 chains by the county surveyor's measurement. By proportionate measurement in this case the sixteenth-section corner should be set at 19.77 chains north of the quarter-section corner, instead of 20 chains north of said corner, as represented on the official plat. In this manner the discrepancies between original and new measurements are equitably distributed.

Summary

3-92. By way of recapitulation it is emphasized that when entrymen have acquired title to certain legal subdivisions they have become the owners of the identical ground area represented by the same subdivisions upon the official plat. It is a matter of expert or technical procedure to mark out the legal subdivisions called for in a patent, and entrymen are advised that a competent surveyor should be employed. The surveyor must identify the section boundaries and locate the legal center of the section in order to determine the boundaries of a quarter section. Then, if the boundaries of quarter-quarter sections, or fractional lots, are to be determined on the ground, the boundaries of the quarter section must be measured, and the sixteenth-section corners fixed in accordance with the proportional distances represented upon the approved plat. Finally, the legal center of the quarter section may be duly located. Thus will be produced in



Official measurements.

Remeasurements.

FIGURE 50.—Examples of subdivision by survey showing relation of official measurements and calculated distances to remeasurements, and indicating proportional distribution of differences.

the field the figure represented upon the plat, every part of the former in true proportion to the latter, where the elements of absolute distance and area have given way to corresponding proportional units as defined by fixed monuments established in the original survey.

SURVEY OF PARTS OF SECTIONS

3-93. In rare cases portions of the section boundaries are impassable or so insecure that acceptable monumentation is impracticable, and yet a need exists for survey of the accessible area. Since rules covering every set of conditions cannot be given, the methods ordinarily are carried in the special instructions. Figures 51 and 52 show rectangular boundaries of parts of regular sections. A random subdivision-of-section line is run closing the area to be surveyed, each course parallel to the governing boundary, with lengths in multiples of 20 chains. The closing error is then distributed as provided in section 5-43 and monuments established. Figures 53 and 54 show rectangular boundaries of parts of closing sections. Fractional lottings are indicated. In figure 53 the whole closing error in latitude is placed as normally in the north tier of lots. In figure 54 the whole closing error in departure is placed as normally in the west range of lots. In all cases the interior sixteenth-section corners and

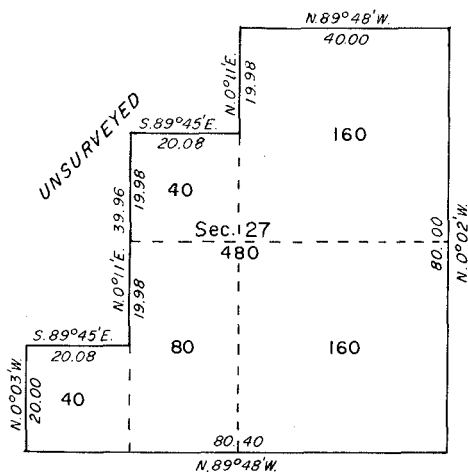


FIGURE 51.—Rectangular boundaries of parts of a regular section.

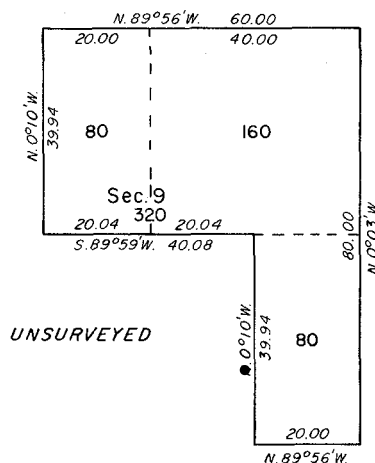


FIGURE 52.—Rectangular boundaries of parts of a regular section.

the center quarter-section corner are monumented at turning points of the lines actually run.

3-94. The field notes show only the true line courses and distances, the usual topography, the description of monuments, and a description of the difficulties which warranted an elimination of parts of the section or sections.

3-95. To subdivide a partly surveyed section, the remaining subdivision-of-section lines within the surveyed area would be determined by running straight lines between the nearest established control for the sectional center lines.

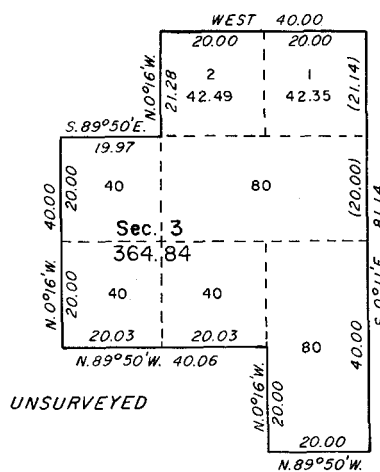


FIGURE 53.—Rectangular boundaries of parts of a section adjoining the north boundary.

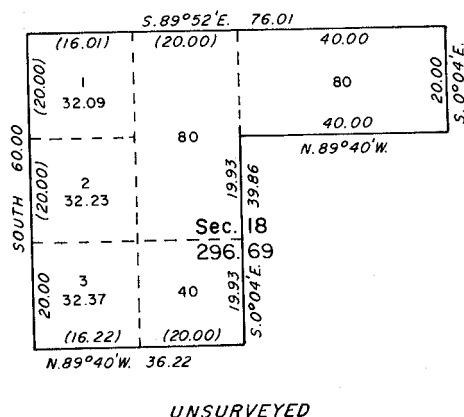


FIGURE 54.—Rectangular boundaries of parts of a section adjoining the west boundary.

The position for the center quarter-section corner is at the intersection of the center lines, unless previously marked. The remaining interior sixteenth-section corners on the sectional center lines are at midpoints between the exterior quarter-section corners and the center quarter-section corner, except within the sections normally fractional. The center lines of the quarter sections would be completed on a similar plan. In all sections normally fractional the excess or deficiency would be placed in its normal position.

3-96. Although the running of traverse lines on the margin of impassable areas has been largely discontinued, such a survey is sometimes called for where rectangular boundaries cannot otherwise be completed within the section. The method should be authorized in the special instructions only when supported by ample justification. In such surveys the angle points of the traverse line are given serial numbers in each fractional section, and the points are monumented. The subdivision-of-section lines are protracted only, unless a definition upon the ground is justified.

FRACTIONAL TOWNSHIPS

3-97. The regular procedures described for subdividing full townships cannot always be adopted. A township invaded by a large mean-

derable body of water, impassable objects, or a State, reservation, or grant boundary may lack a full linear south or east boundary. If it has been found advisable to run section lines as offsets to the township exteriors, the fractional section lines south and east of these controlling lines are projected opposite to the usual directions. The fractional measurements and the resulting fractional lots are placed against the irregular boundary. If only the north or west part of a fractional township is involved, no departure from the regular order of subdivision is necessary, since fractional measurements on the exterior and subdivisional lines, and the resulting fractional lots, will be placed to the north and west against the irregular boundary.

3-98. Where no part of the south boundary of a township can be regularly established, the subdivision may proceed from north to south and from east to west, throwing fractional measurements and areas against the west boundary and the meanderable stream or other boundary limiting the township on the south. If the east boundary is without regular section corners and the north boundary has been run eastwardly as a true line, with section corners at regular intervals of 80 chains, the subdivision of the township may be made from west to east. In that case the fractional measurements and areas are thrown against the irregular east boundary. On the other hand, if the north boundary of section 6 is fractional, a sectional guide meridian, initiated at the easternmost regular section corner on the north boundary, is projected to the south to take the place of a governing east boundary. The subdivisional survey is then projected from north to south and from east to west, with fractional measurements and resulting fractional lots on the east, south and west boundaries of the township. Figures 55 through 58 illustrate the principles which control the subdivision of partial townships.

3-99. In the case of fractional townships the sections bear the same numbers they would have had if the townships were complete. That is, the section numbers are those relating to the governing boundaries.

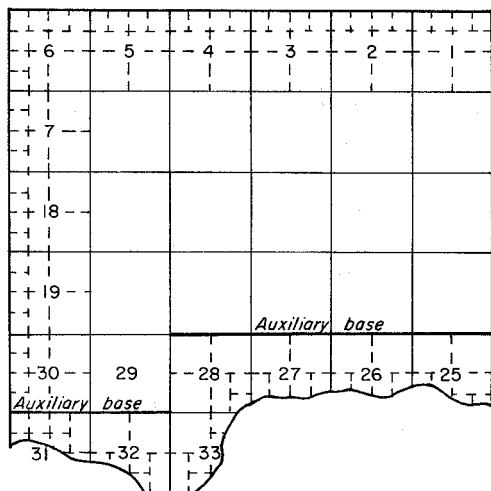


FIGURE 55(a).—Use of auxiliary base.

EXTENSION AND COMPLETION SURVEYS

3-100. Surveys coming before the Bureau of Land Management sometimes involve the continuation of the subdivisional survey of townships previously subdivided in part only. These surveys include the completion of partially surveyed sections or of sections containing outlying areas protracted as surveyed. If defective conditions are encountered in the previously established surveys, the problems concerning the procedure to be adopted multiply rapidly and require the greatest skill on the

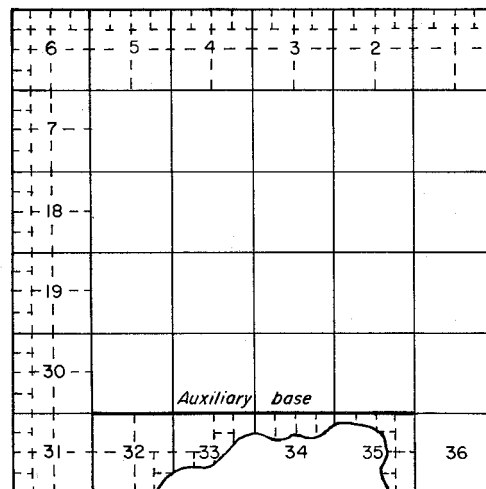


FIGURE 55(c).—Use of auxiliary base.

part of the surveyor. In the construction of new township plats the former practice of platting outlying areas of sections protracted as surveyed has been abandoned as unsatisfactory and inconsistent with the surveying laws.

3-101. Most original surveys that are now to be extended were executed many years ago when the remaining areas were considered wastelands. Due to the ravages of time and the inferior monumentation of the early surveys, obliteration may be so far advanced that resurveys are needed to identify and remonument the limiting boundaries of the area to be surveyed. The surveyor often must retrace

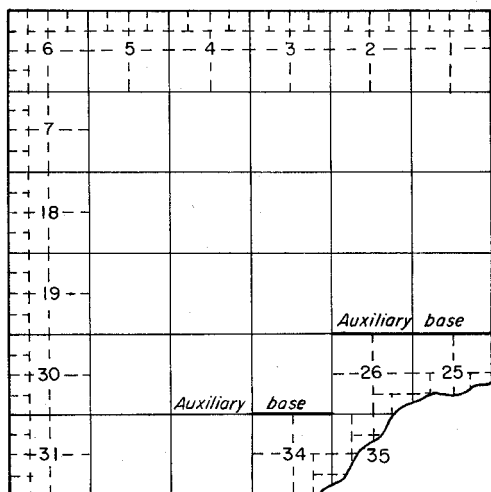


FIGURE 55(b).—Use of auxiliary base.

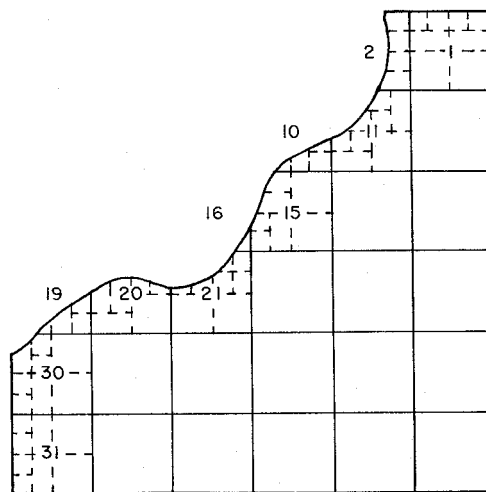


FIGURE 56.—Regular subdivision of fractional township.

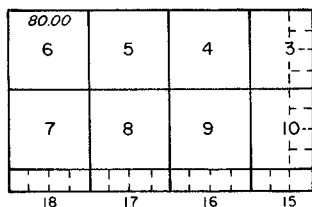


FIGURE 57.—Subdivision from north to south, and from west to east.

additional lines that are not the boundaries of sections containing the new areas to be surveyed. The theoretical position of a lost corner on such lines may be at variance with an unofficial corner established by local survey and recognized by the owners of the private lands affected. Controversy is avoided if reestablishments are confined to corners that control the position of the section boundaries or the subdivision-of-section lines of the public lands to be surveyed. Identified original corners adopted as control in reestablishing corners of the public land sections are rehabilitated but not remonumented in such cases. Corner restorations are made in accordance with the provisions of chapter V.

3-102. The field notes of necessary resurveys should include an explanation of their purpose and extent, including all needed historical references to the related prior surveys. The detail is written in the usual field note

record form, following the introductory statement.

The plat, in addition to the usual data, may carry a marginal memorandum or diagram that clearly defines what lines of the prior survey have been retraced as a basis for extending the new lines. If no changes are made in the former lottings and areas in the resurveyed portions, it is stated that the lottings and area remain as shown on the plat or plats approved—(date or dates).

Completion of Partially Surveyed Sections

3-103. In extending fragmentary surveys, first consideration is given to the completion of partially surveyed sections. If outlying portions of sections have been returned as surveyed on the previous plat, it is usually necessary to complete the survey of each section in such a way as to protect acquired rights. The procedure adopted must fix the remaining quarter-section corners in a position which will control the center lines as necessary to retain the form of the original areas within reasonable limits.

3-104. The new quarter-section corners are regarded as reasonably fixed when (1) the alignment does not exceed 21' from a cardinal course and (2) the measurement does not exceed 25 links from 40 chains, or in proportion when the opposite portion of the section boundary was returned as more or less than 40 chains. This concession as to limits is made in the interests of simplicity where the rectangularity of both old and new surveys can thus be maintained.

3-105. The position of the quarter-section corner on a new opposite boundary is controlled from only one direction if the old opposite distance was made to count from one direction only. If the old opposite distance was made to count from two directions, the position of the new quarter-section corner is controlled from the two directions. The lengths of the two portions of the new line are made proportional to the two parts of the old opposite boundary.

3-106. Given an original survey which is within rectangular limits, the survey of a fractional section is completed on the same plan begun in the original survey. When irregularity is developed, the simplest method of sur-

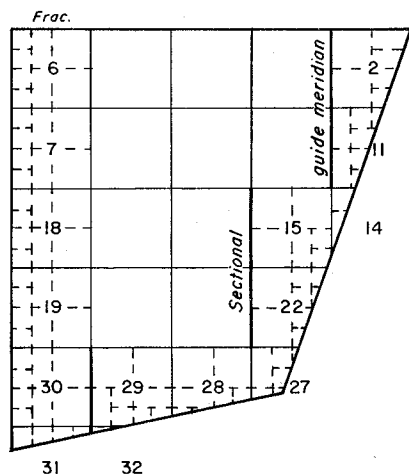


FIGURE 58.—Subdivision from north to south, and from east to west.

vey that will correct irregularities and provide an early resumption of regularity in the new subdivisional lines is adopted. The general rule is that each completed section will have four regular boundaries without offsets, with four governing section corners and four controlling quarter-section corners in such position as to maintain the integrity of the fractional areas shown upon the original plat.

3-107. Modification of the general rule is necessary where completing each of two sections in the above manner would cause an overlap or hiatus. In such a case each section is completed theoretically without regard to the other, and the position of each center line is fixed. The most reasonable position for a common boundary between the two sections is then determined, and the new quarter-section corners are established at points which maintain the center lines in their positions. If the theoretical position for each quarter-section corner falls within 25 links of a common point, with allowance for variance in length of the center line, one corner may be established which will secure maximum regularity in both sections.

3-108. The possible combinations of uncompleted sections are too numerous to discuss fully here. Directions will be given in the special instructions for the cases involved in an assignment, and the surveyor should seek advice from the proper administrative office when irregularities develop. A diagram showing the exact field conditions should always accompany his report.

3-109. A private survey made for the purpose of marking on the ground a theoretical line, platted but not run by the Government, where executed within allowable departure from cardinal course, and relied upon by owner under title passed by the United States in the placing of improvements upon the patented land, will not be disturbed, but it will be adopted by the Government as a boundary for closure of the survey of the adjoining public land. *Algoma Lumber Co. v. Kruger*, 50 L.D. 402 (1923).

3-110. The best test of the fitness of a proposed method for the completion of partially surveyed sections is to plat the subdivisional lines by protraction. Thereupon the regular rules for subdivision of sections should be ap-

plicable. The position of the new quarter-section corners, established to control the subdivision of the section in question, must be such as to permit the center lines to the opposite original quarter-section corners to be connected in harmony with conditions shown on the original plat, disregarding the effect upon the subdivision of the newly surveyed land. Likewise, the lines connecting the sixteenth-section corners on the opposite boundaries of a quarter section must conform to the conditions represented on the original plat. When the subdivision-of-section lines are platted, the section is satisfactory if the integrity of the original areas is in no way violated.

3-111. The following guidelines should be followed in platting:

(1) The new areas should be complementary to the original areas by the extension of the subdivision-of-section lines as already protracted upon the original plat, except as poorly shaped lots, or lots of too great or too little area, would result in violation of the regular rules for subdivision of sections.

(2) In the interest of regularity and simplicity of platting, the same meridional limit may be permitted as is ordinarily allowed in latitudinal section lines. A section may be considered regular if its boundaries do not depart more than 21' from a cardinal course in alignment and no more than 25 links from 40 chains in measurement between the section and quarter-section corners. Such regular sections may be subdivided into regular quarter sections and quarter-quarter sections as far as possible. A section having three regular boundary lines may be subdivided in accordance with the usual rules for subdividing sections along the north and west boundaries of a normal township. A section having two adjacent regular boundary lines may be subdivided by the same manner in which section 6 of a normal township is treated. All other sections should be treated as irregular, with subdivision-of-section lines protracted to mid-points on the boundaries of the quarter sections, except as a calculated proportional position for a sixteenth-section corner is made necessary by the showing of the original plat.

(3) All new fractional lots are numbered beginning with the next higher number in the

series shown on the previously approved plat, and proceeding in the usual order. The new series may begin with No. 1 if the fractional parts of the original area are not designated by lot number.

Completion of Township Subdivision

3-112. Only after the partially surveyed sections have been completed should the surveyor proceed with the subdivision of the remaining portions of the township. If no irregularities are found in the previously established lines the new survey may proceed normally. If defective conditions are encountered, the irregularities are not extended into unsurveyed sections any farther than necessary to incorporate the resulting fractional measurements into suitable fractional lots adjoining the former surveys. Preference should be given to extending all surveys from south to north and from east to west. If a better control is available by reversing the procedure in one or both directions, resulting in a simpler survey by minimizing the number of extra corners as well as fractional lots, reversal of the procedure is warranted.

3-113. In the event that the previously surveyed subdivision lines are defective, the new section lines may serve the function of a sectional guide meridian or a sectional correction line as required. The corners from which the new surveys are initiated are established as corners of four sections, or of two sections as appropriate. Where new section lines cannot be connected regularly with the previously established section corners by random and true line not exceeding 21' from cardinal, a closing section corner is established at intersection with the line of the old survey. The fractional measurements of the closing section lines are placed adjacent to the old surveys. The original lines forming the boundary of the lands to be surveyed are retraced, as already provided and the marks upon the original corners are appropriately modified as necessary. New quarter-section corners marked to control the subdivision of the new sections are established on the original lines at midpoints between the closing section corners, or at 40 chains from one direc-

tion, according to the manner in which a new section is subdivided.

3-114. There are often two or more ways in which a fractional subdivision may be completed, but careful study of a sketch plat representing existing conditions will generally reveal the superiority of one method over another.

MEANDERING

3-115. The traverse of the margin of a permanent natural body of water is termed a meander line. All navigable bodies of water and other important rivers and lakes are segregated from the public lands at mean high-water elevation. In original surveys, meander lines are run for the purpose of ascertaining the quantity of land remaining after segregation of the water area.

The running of meander lines has always been authorized in the survey of public lands fronting on large streams and other bodies of water. But the mere fact that an irregular or sinuous line must be run, as in the case of a reservation boundary, does not entitle it to be called a meander line except where it closely follows the bank of a stream or lake. The legal riparian rights connected with meander lines do not apply in the case of other irregular lines, as the latter are strict boundaries.

Low-water mark is the point to which a river or other body of water recedes, under ordinary conditions, at its lowest stage. High-water mark is the line which the water impresses on the soil by covering it for sufficient periods to deprive it of vegetation. The shore is the space between the margin of the water at its lowest stage and the banks at high-water mark. *Alabama v. Georgia*, 64 U. S. 505 (1859).

Numerous decisions in the United States Supreme Court assert the principle that meander lines are not boundaries defining the area of ownership of lands adjacent to the water. The general rule is that meander lines are run not as boundaries, but to define the sinuosities of the banks of the stream or other body of water, and as a means of ascertaining the quantity of land embraced in the survey; the stream, or other body of water, and not the meander line as actually run on the ground, is the bound-

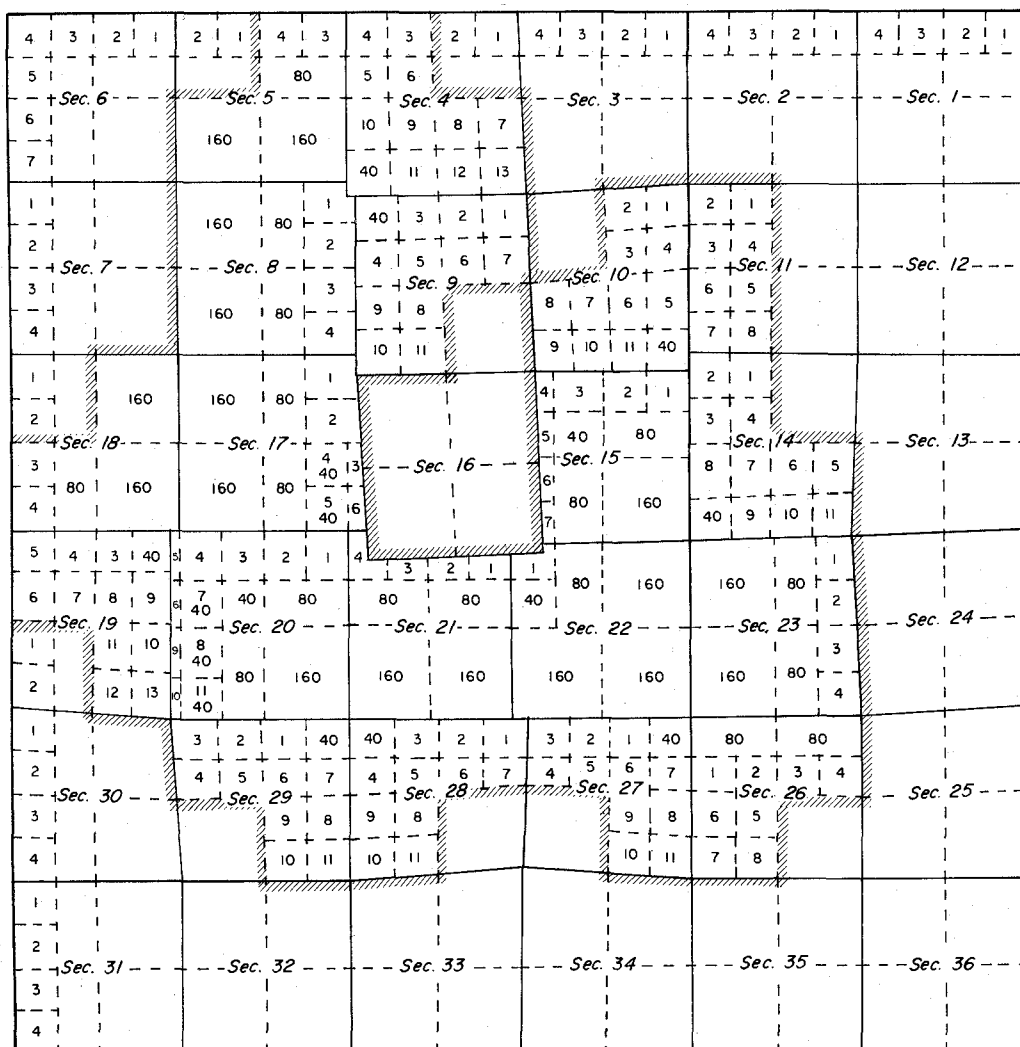


FIGURE 59.—Example showing completion of partially surveyed sections and completion of subdivisional lines of a township with necessary lottings.

ary. When by action of water the bed of the body of water changes, high-water mark changes, and the ownership of adjoining land progresses with it. *Lane v. United States*, 274 Fed. 290 (1921).

Meander lines will not be established at the segregation line between upland and swamp or overflowed land, but at the ordinary high-water mark of the actual margin of the river or lake on which such swamp or overflowed lands border.

3-116. Practically all inland bodies of water pass through an annual cycle of changes, be-

tween the extremes of which will be found mean high water. In regions of broken topography, especially where bodies of water are bounded by sharply sloping lands, the horizontal distance between the margins of the various water elevations is comparatively slight, and the surveyor does not experience much difficulty in determining the horizontal position of mean high-water level with approximate accuracy. Where the meanderable bodies of water are bordered by relatively flat lands, the horizontal distance between the successive levels is relatively great. The most reliable indication of

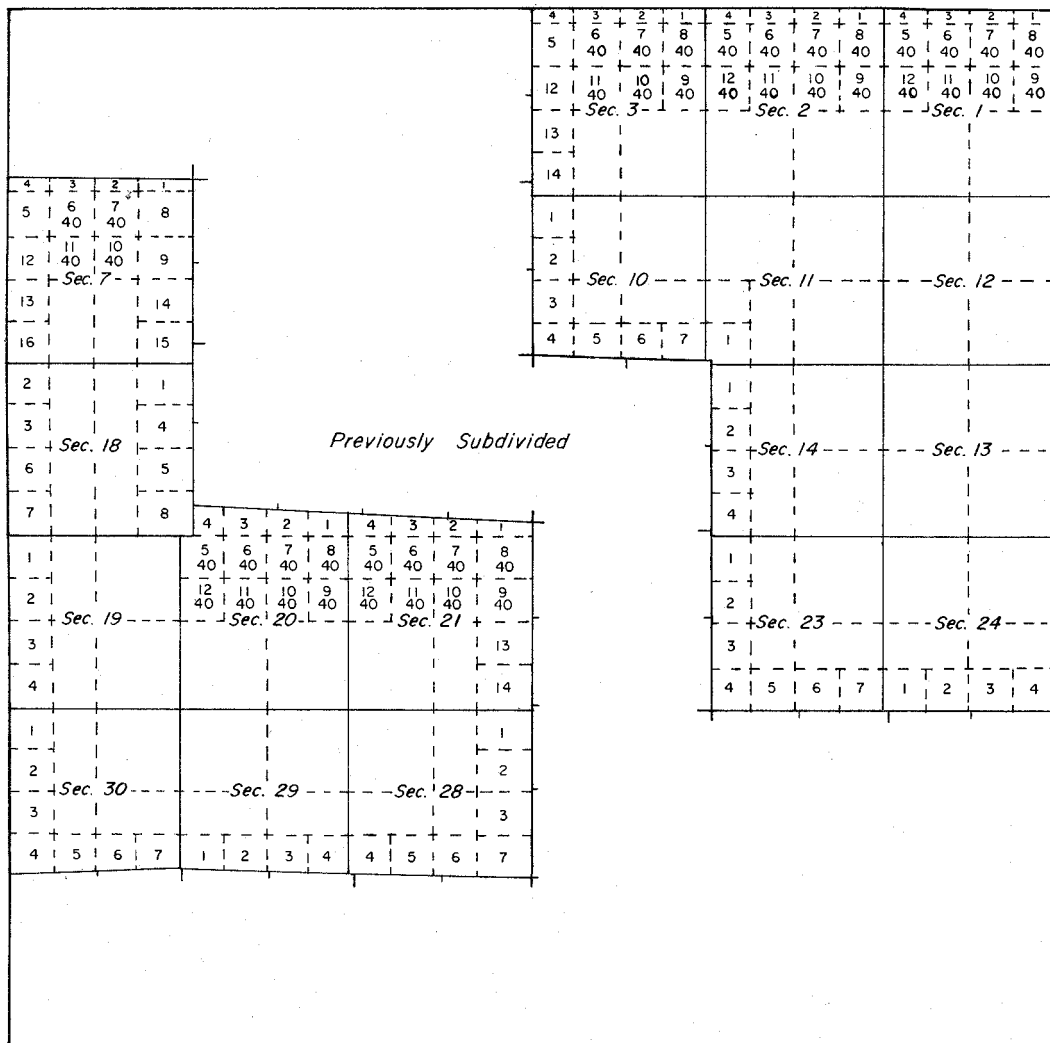


FIGURE 60.—Example showing completion of subdivisional lines of a township where outlying parts of sections returned earlier have been cancelled.

mean high-water elevation is the evidence made by the water's action at its various stages, which are generally well marked in the soil. In timbered localities a very certain indication of the locus of the various important water levels is found in the belting of the native forest species.

Mean high-water elevation is found at the margin of the area occupied by the water for the greater portion of each average year. At this level a definite escarpment in the soil is generally traceable, at the top of which is the true position for the meander line. A pronounced

escarpment, the result of the action of storm and flood waters is often found above the principal water level, and separated from the latter by the storm or flood beach. Another, less evident, escarpment is often found at the average low-water level, especially of lakes, the lower escarpment being separated from the principal escarpment by the normal beach or shore. While these questions properly belong to the realm of geology, they should not be overlooked in the survey of a meander line.

Where native forest trees are found in abundance bordering bodies of water, those trees

showing evidence of having grown under favorable site conditions will be found belted along contour lines. Certain mixed varieties common to a particular region are found only on the lands seldom if ever overflowed. Another group are found on the lands which are inundated only a small portion of the growing season each year, and indicate the area which should be included in the classification of the uplands. Other varieties of native forest trees are found only within the zone of swamp and overflowed lands. All timber growth normally ceases at the margin of permanent water.

3-117. A meander corner is established at every point where a standard, township, or section line intersects the bank of a navigable stream or other meanderable body of water. No monument should be placed in a position exposed to the beating of waves and the action of ice in severe weather. In such cases a witness corner should be established on the line at a secure point near the true point for the meander corner. The distance across a body of water is ascertained by triangulation or direct measurement, and the full particulars are given in the field tablets.

3-118. Inasmuch as it is not practicable in public-land surveys to meander in such a way as to follow and reproduce all the minute windings of the high-water line, the United States Supreme Court has given the principles governing the use and purpose of meandering shores in its decision in a noted case as follows:

Meander lines are run in surveying fractional portions of the public lands bordering on navigable rivers, not as boundaries of the tract, but for the purpose of defining the sinuosities of the banks of the stream, and as the means of ascertaining the quantity of land in the fraction subject to sale, which is to be paid for by the purchaser. In preparing the official plat from the field notes, the meander line is represented as the border line of the stream, and shows to a demonstration that the watercourse, and not the meander line as actually run on the land, is the boundary. *Railroad Co. v. Schurmeier*, 74 U.S. 272 (1868).

3-119. The surveyor commences at one of the meander corners, follows the bank or shore line, and determines the length and true bearing of each course, from the beginning to the next meander corner. All meander courses refer to the true meridian and are determined with precision. "Transit angles" showing only the

amount of the deviation from the preceding course are not acceptable in field notes of meanders. Where it is impossible to survey the meander line along mean high-water mark, the notes should state the distance therefrom and the obstacles which justify the deviation. A table of latitudes and departures of the meander courses should be computed before leaving the vicinity, and if misclosure is found, indicating error in measurement or in reading courses, the lines should be rerun.

The following items will be noted along the meander line: (1) all streams flowing into a river, lake, or meanderable bayou, with the width at their mouths; (2) the position, size, and depth of springs, and whether the water is pure or mineral; (3) the heads and mouths of all bayous; (4) all rapids and bars, with intersections to the upper and lower ends; (5) the elevation of the banks of lakes and streams, the height of falls and cascades, and the length and fall of rapids; and (6) artificial structures in both land and water areas.

The field notes of meanders show the corners from which the meanders commenced and upon which they closed, and exhibit the meanders of each fractional section separately. Following, and composing a part of the notes, should be given a description of the adjoining land, soil and timber, and the estimated depth of inundation to which the bottom land is subject.

Rivers

3-120. Facing downstream, the bank on the left hand is termed the left bank and that on the right hand the right bank. These terms will be universally used to distinguish the two banks of a river or stream.

Navigable rivers and bayous, as well as all rivers not navigable, the right-angle width of which is 3 chains and upwards, are meandered on both banks, at the ordinary mean high-water mark, by taking the general courses and distances of their sinuosities. Rivers not classed as navigable are not meandered above the point where the average right-angle width is less than 3 chains, except when duly authorized.

Shallow streams and intermittent streams without well defined channel or banks are not meandered, even when more than 3 chains wide.

Tidewater streams are meandered at ordinary mean high tide as far as navigable, even when less than 3 chains wide. Tidewater inlets and bayous are recorded, and are meandered if more than 3 chains in width, but when nonnavigable are not meandered when less than 3 chains wide.

Lakes

3-121. All lakes of the area of 50 acres and upwards, are meandered.

In the case of lakes which are located entirely within the boundaries of a section, a quarter-section line, if one crosses the lake, is run from one of the quarter-section corners, on a theoretical course to connect with the opposite quarter-section corner, to the margin of the lake, and the distance is measured. At the point thus determined a "special meander corner" is established.

Where one or both of the opposite quarter-section corners cannot be established, and in all cases where the distance across a lake exceeds 40 chains or the physical crossing is difficult, a temporary special meander corner is established at the computed intersection with the center line of the section when surveying the meander line. The temporary point is later corrected to the true center line position for monumentation, at midpoint in departure (or latitude), or at proportionate distance in a fractional section.

If a meanderable lake is found to be located entirely within a quarter section, an "auxiliary meander corner" is established at some suitable point on its margin, and a connecting line is run from the monument to a regular corner on the section boundary. A connecting traverse line is recorded, if run, but it is also reduced to the equivalent direct connecting course and distance, all of which is stated in the field notes. Only the course and length of the direct connecting line are shown on the plat of the survey.

The meander line of a lake lying within a section is initiated at the established special or auxiliary meander corner, as the case may be, and continued around the margin of the normal lake at its mean high-water level, to a closing at the point of beginning. All proceedings are fully entered in the field notes.

Artificial lakes and reservoirs are not segregated from the public lands, unless specially provided in the instructions, but the true position and extent of such bodies of water are determined in the field and shown on the plat.

Other exceptions to the general rule are shallow or poorly defined "lakes" which are actually pools that collect because of permafrost and lack of drainage or which are ephemeral desert playas formed seasonally or in wet years. These "lakes" should not be meandered even when larger than 50 acres.

Islands

3-122. Every island above the mean high-water elevation of any meanderable body of water, except islands formed in navigable bodies of water after the date of the admission of a State into the Union, is located by triangulation or direct measurement or other suitable process, and is meandered and shown upon the official plat.

Even though the United States has parted with its title to the adjoining mainland, an island in a meandered body of water, navigable or nonnavigable, in continuous existence since the date of the admission of the State into the Union, and omitted from the original survey, remains public land of the United States. As such the island is subject to survey. This is because such islands were not a part of the *bed* of the stream at the date of Statehood, and therefore their title remained in the United States, subject to survey and disposal when identified. The riparian right that attaches to the lottings along the meander line of the mainland pertains only to the bed of the stream, and to such islands as may form within the bed subsequent to the disposal of the title. The proof of the time of the formation of islands is often difficult. It is the practice to make a careful examination of the history of an island in relation to the question of its legal ownership.

Islands that have been given well-known proper names are so identified, both in the field notes and on the plat. Sometimes there are a number of islands in the same section without proper names. Some may have been surveyed, others omitted. Of the latter, some may rightfully belong to the State, some to a riparian

proprietor, so that any system of numbering may be uncertain, and if used may still be confused with a lot number, if and when surveyed. For these reasons their identification may be uncertain unless the following rule is applied:

Where there are several unnamed islands within the same section, these will be referred to in the field notes (when surveyed) according to the lot number (Island designated as lot No. —) that is assigned on the plat, excepting that islands which are crossed by section line boundaries, or by a center line of the section, are readily identified by location.

Any township boundary or section line which will intersect an island is extended as nearly in accordance with the plan of regular surveys as conditions permit, and the usual township, section, quarter-section, and meander corners are established on the island. If an island falls in two sections only, the line between the sections should be established in its proper theoretical position based upon suitable sights and calculations. If an island falls entirely in one section, and is large enough to be subdivided (over 50 acres in area), a suitable sight or calculation is made to locate on the margin of the island an intersection with the theoretical position of any suitable subdivision-of-section line. At the point thus determined a "special meander corner" is established. In the case of an island falling entirely in one section and too small to be subdivided, an 'auxiliary meander corner' is established at any suitable point on its margin, which is connected with any regular corner on the mainland. The direct course and length of the connecting line is given in the field notes and shown on the plat.

The meander line of an island is surveyed in harmony with principles and rules heretofore stated. All township and section lines crossing the island are shown on the plat. If the island is large enough to be subdivided, the subdivision is accomplished by the protraction of suitable subdivision-of-section lines in their correct theoretical position.

Under special circumstances where administration or disposal requires no subdivision, an island is given a tract number within a township. In such cases, the section lines need not be extended to the island.

Agricultural upland within the limits of swamp and overflowed lands should be so classified and shown upon the plat accordingly, but such land is not meandered as an island.

Use of Photogrammetry

3-123. Where conditions are favorable, meander lines may be surveyed by the process of photogrammetry after the meander corners have been established in the regular manner. The field notes will state what lines were so determined and the date and identification of the photography.

LIMITS OF CLOSURE

3-124. The "error of closure" of a survey is defined in general terms as the ratio of the length of the line representing the equivalent of the errors in latitude and departure to the length of the perimeter of the figure constituting the survey. However, with due regard for the controlling coordinate governing lines of a rectangular survey, accuracy in latitude is not permitted to offset gross error in departure, or vice versa. A double test is therefore applied to United States rectangular surveys in place of the one expressed in general terms.

The "limit of closure" set for the public land surveys may now be expressed by the fraction $1/905$, provided that the limit of closure in neither latitude nor departure exceeds $1/1280$. Where a survey qualifies under the latter limit, the former is bound to be satisfied. An accumulative error of $6\frac{1}{4}$ links per mile of perimeter, in either latitude or departure, will not be exceeded in an acceptable survey.

The latitudes and departures of a normal section shall each close within 25 links, of a normal range or tier of sections within 88 links, and of a normal township within 150 links. The boundaries of each fractional section including irregular claim lines or meanders, or the meanders of an island or lake in the interior of a section, should close within a limit to be determined by the fraction $1/1280$ for latitude or departure considered separately. The same rule applies to all broken or irregular boundaries. All closings will be computed in the field.

Stricter limits of closure will be specified in the special instructions for classes of surveys where higher precision is indicated by the values involved.

MARKING LINES BETWEEN CORNERS

3-125. The survey is marked upon the ground in the following ways:

(a) The regular corners of the public-land surveys are marked by fixed official monuments as described in chapter IV.

(b) The relation to natural topographic features is recorded in detail in the field notes. (chapter VIII).

(c) The locus of the lines is marked upon forest trees by blazing and by hack marks. Figures 61 and 62. However, in conformity with the National Environmental Policy Act of 1969, the operational need for the marking of lines should be weighed against possible esthetic damage. If special precautions are to be taken in this regard, they should be set out in the special instructions. Also, in the case of resurveys in areas of mixed public and private lands, it may be necessary to restrict the blazing to trees on public land. The surveyor on the ground should apply good judgment in particular cases not covered by his instructions. Where it has been determined that lines will be marked, the methods discussed here are intended to fix the lines permanently with the minimum environmental effect.

A *blaze* is a smoothed surface cut upon a tree trunk at about breast height. The bark

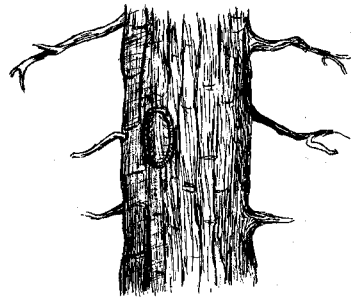


FIGURE 62.—A line blaze.

and a small amount of the live wood tissue are removed with an axe or other cutting tool, leaving a flat surface which forever brands the tree. The size of the blaze depends somewhat upon the size of the tree, but should not be made larger than the surface of an axe blade. A blaze five or six inches in height and from two to four inches in width is usually ample.

A *hack* is a horizontal notch cut well into the wood, also made at about breast height. Two hacks are cut to distinguish them from other, accidental marks. A vertical section of the finished hack marks resembles a double-V extending across a tree from two to six inches depending upon the diameter of the tree.

The blaze and hack mark are equally permanent, but so different in character that one mark should never be mistaken for the other. The difference becomes important when the line is retraced in later years.

Trees intersected by the line have two hacks or notches cut on each of the sides facing the line, without any other marks whatever. These are called sight trees or line trees. A sufficient number of other trees standing within 50 links of the line, on either side of it, are blazed on two sides quartering toward the line, in order to render the line conspicuous and readily to be traced in either direction. The blazes are made opposite each other coinciding in direction with the line where the trees stand very near it and approaching nearer each other toward the line the farther the line passes from the blazed trees. Figure 63.

The lines should be so well marked as to be readily followed and the blazes plain enough to leave recognizable scars as long as the trees stand. This can be accomplished by blazing just

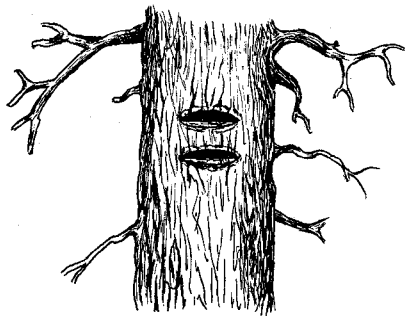


FIGURE 61.—Hack marks on a line tree.



FIGURE 63.—Marking a line through timber.

through the bark into the live wood tissue. The blazes should be narrow so that they will heal before decay begins, and special care should be taken not to loosen the cambium layer around the blaze, since this will prevent overgrowth. Where trees have branches growing to the ground, the blazes may be omitted unless it is necessary to remove the branches to permit sighting.

Lines are also marked by cutting away enough of the undergrowth to facilitate cor-

rect sighting of instruments. Where lines cross deep wooded valleys, by sighting over the tops, the usual blazing of trees in the low ground when accessible will be performed. The undergrowth will be especially well cut along all lines within distances of 5 chains of corner monuments and within 2 chains of arteries of travel, but the cutting of the undergrowth may be omitted in deep untraveled ravines unless necessary for accurate sighting or measurement.

Line trees and blazing are marked only with

reference to the established true line. Where lines are run by the "random and true" line method, the marking of line trees and the blazing is accomplished by returning over the line after all corrections or adjustments to the final line are definitely known. A sufficient number of temporary stakes should be set along a random line to render it generally unnecessary to rerun the true line instrumentally merely for the purpose of blazing the line through timber. This can usually be accomplished by properly estimating the distance from the temporary stakes, but intersections with line trees will be made with precision, and distances thereto accurately measured.

SUMMARY OF OBJECTS TO BE NOTED, AND SKETCHES

3-126. The field notes and plat of a survey furnish not only a technical record of the procedure, but also a report upon the character of the land, soil and timber traversed by the survey, and the topographical features along line, with accurate connections showing the relation of the rectangular surveys to other surveys, to natural objects, and to improvements. A triple purpose is thus served: (1) the technical procedure is made a matter of official record; (2) general information relating to a region is gathered; and, (3) the "calls" of the field notes and the representations of the plat in respect to objects along the surveyed lines furnish important evidence by which the locus of the survey becomes practically unchangeable as contemplated by law.

The specimen field notes and plats are intended to standardize the form of record. Special matters relating to these subjects are discussed in chapters VIII and IX. The technical and topographical features which are to be carefully observed and recorded in the field during the progress of the public-land surveys are:

(1) The course and length of every line run, all necessary offsets therefrom, the reason for making them, and the method employed.

(2) The kind and diameter of bearing trees, the course and distance from their respective corners, and the markings; all bearing objects and marks thereon, if any; and the position of witness corners relative to the true corners.

(3) The kind of material of which corner monuments are constructed, their dimensions and markings, depth set in the ground, and their accessories.

(4) Trees on line. The name, diameter and distance on line to trees which it intersects, and their markings.

(5) Intersections by line of land objects. The distance at which the line intersects the boundary lines of a reservation, townsite, or private claim, noting the exact bearing of such boundary lines, and the distance to the nearest boundary corner; the center line of a railroad, canal, ditch, electric transmission line, or other right-of-way across public lands, noting the width of the right-of-way and the bearing of the center line; the change from one character of land to another, with the approximate bearing of the demarcation, and the estimated height in feet of the ascents and descents over the principal slopes traversed, with the slope direction; the distance to and the direction of the principal ridges, spurs, divides, rimrock, precipitous cliffs, etc.; the distance to where the line enters or leaves heavy or scattering timber, with the approximate bearing of the margin of heavy timber, and the distance to where the line enters or leaves dense undergrowth.

The amount of ascent or descent is only required in rough country where it will be of significant value to later surveyors. Where it is omitted the slope on which a corner is situated must be shown. The same requirement applies where the slope is given as general or broken and the slope at the corner differs from the general slope.

(6) Intersections by line of water objects. Unmeandered rivers, creeks and smaller watercourses which the line crosses; the distance measured on the true line to the center in the case of smaller streams, and to both banks in the case of larger streams, the course down stream at points of intersection, and their widths on line, if only the center is noted. Intermittent watercourses, such as ravines, gulches, arroyos, draws, dry-drains, etc.

(7) The land's surface; whether level, rolling, broken, hilly or mountainous.

(8) The soil; whether rocky, stony, gravelly, sandy, loam, clay, etc.

(9) Timber; the several kinds of timber and undergrowth, in the order in which they predominate. Items (7), (8), and (9) are summarized at the end of each mile in field notes of original survey. See sample notes.

(10) Bottom lands to be described as upland or swamp and overflowed, as contradistinguished under the law, noting the extent and approximate position of the latter and depth of overflow at seasonal periods. Sections 7-95 to 7-99.

(11) Springs of water, whether fresh, saline, or mineral, with the course of the stream flowing therefrom. The location of streams, springs, or water-holes, which because of their environment may be of value in connection with the utilization of public grazing lands, and which may be designated as public watering places, will be specially noted.

(12) Lakes and ponds, describing their banks, tributaries and outlet, and whether the water is pure or stagnant, deep or shallow.

(13) Improvements; towns and villages; post offices; occupancy; houses or cabins, fields, or other improvements; mineral claims; mill-sites. United States location monuments and all other official monuments not belonging to the system of rectangular surveys to be located by bearing and distance or by intersecting bearings from given points.

(14) Coal banks or beds, ore bodies, with description as to quality and extent; mining surface improvements and underground workings; and salt licks. Reliable information that can be obtained respecting these objects, whether on the line or not, should appear in the general description.

(15) Roads and trails, with their directions, whence and whither.

(16) Rapids, cataracts, cascades, or falls of water, in their approximate position and estimated height of fall in feet.

(17) Stone quarries and ledges of rocks, with the kind of stone they afford.

(18) Natural curiosities, petrifications, fossils, organic remains, etc.; also all archaeological remains, such as cliff dwellings, mounds, fortifications, or objects of like nature.

(19) *The magnetic declination.*—To be included in the transcribed field notes, in the gen-

eral description (item 20), including the observed local attraction within the area of the survey. The average value over the area surveyed will be shown on the plat.

(20) *General Description.*—The above information is summarized by townships in a general description which concludes the field notes of every survey. The general description embraces more comprehensive details of the characteristics of the region than is feasible to cover as an intimate part of the technical record of the survey, as follows:—

Land.—A general outline of the drainage and topographical features of the township and approximate range of elevation above sea level.

Soil.—The prevailing and characteristic soil types. (See special reference to soil classification, chapter VII).

Timber.—The predominant forest species, age, size, condition, etc.

Evidence of mineral.—Known bodies of mineral, and lands whose formation suggests mineral-bearing characteristics, especially with reference to lands of volcanic or igneous origin, are listed by appropriate legal subdivision, with brief description of the mineral indications. If there is no apparent indication of mineral deposits, a report to that effect is embodied in the general description.

Watering places.—The areas embracing all streams, springs, or water holes as may be of special value as public watering places, in connection with the utilization of public grazing lands, are listed by appropriate legal subdivision, with brief description of the nature of such water supply.

Settlement.—The extent of the settlement at the time of the survey.

Industry.—The industrial possibilities of the township, especially as to the adaptability of the region to agricultural pursuits, stock raising, lumbering, mining, or other profitable enterprise.

Sketch Plat

3-127. In addition to the field notes the surveyor is required to prepare an outline diagram showing the course and length of established lines with connections, and a topographical sketch embracing the features usually shown

upon the official township plat. These maps are made to scale, drawn in pencil only, if desired, and are kept up with the progress of the field work. If the area of the survey is covered by accurate maps or recent aerial photographs, the topographic detail may be omitted from the sketch except in the immediate vicinity of the lines; otherwise, the interiors of the sections should be completed. The topographical features are sketched while in view, and the position of the details to be shown on the completed plat are located with an accuracy commensurate

with their relative importance. The design of the specimen township plat should be followed closely in preparing the sketch plat. It is generally desirable to use separate sheets for the line diagram and the topography. These maps form the basis of the official plat, the ultimate purpose of which is a complete graphic representation of the public lands surveyed.

The subjects of the field sketches; accuracy of detail in special cases; use of aerial photographs; map features within the interior of sections; etc., are enlarged in chapter IX.